1958 CONVENTION—CHICAGO—FEBRUARY 24-27, 1958

NOVEMBER 1957
No. 5
VOL. 29

JOURNAL
OF THE AMERICAN CONCRETE INSTITUTE

THIS MONTH

Papers and Reports 369-420

Winter Concreting in Europe ..... E. G. SWENSON 369

Variation of Mortar and Concrete Properties with Temperature ..... J. C. SAEMANN and G. W. WASHA 385

A Critical Look at Slab Design Methods ..... K. E. McKEE and E. I. FIESENHEISER 397

Bearing Capacity of Concrete ... WILLIAM SHELSON 405

Temperature Stresses in Continuous Frames ..... SAM HASSID 415

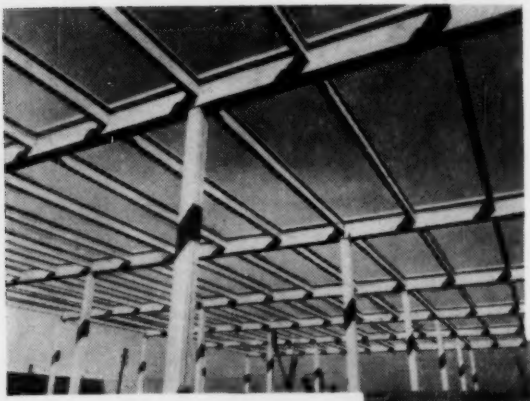
Concrete Briefs 421-424

Current Reviews 425-440

News Letter 1-34

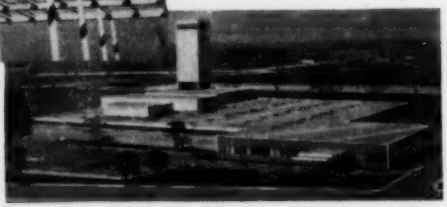
ACI
PROCEEDINGS
VOL. 54

FRAMEWORK OF THE FUTURE IS GOING UP *Today!*



130 Columns
95 Girders
425 Purlins

. . . Up in Just 7 Weeks



CHECK THESE CONCRETE FACTS

Here's what architect and owner want in a new building. Here's what precast and prestressed concrete gives them:

- a maintenance-free, corrosion-free structure
- elimination of fire hazard, hence favorable insurance rates
- streamline, smooth surfaces easy to keep clean, new-looking and sanitary
- flexibility for expansion through variety of shapes, sizes and weights made-to-order at no premium cost
- economy through speedy erection in days or weeks, from on-job or off-job casting plants
- immediate availability of units, produced as needed

● quicker starts, earlier finishes by using 'Incor' high early strength cement, in assembly line production through fast stripping and re-use of forms

● Savarin's new coffee plant highlights the slim, clean functional beauty of precast concrete. This efficient plant is proof of modern concrete's versatility, speed and economy of erection.

Dependable 'INCOR'* — America's first high early strength cement—is a major reason why precast, prestressed buildings such as this are the Framework of the Future rising everywhere *Today.*

*Reg. U. S. Pat. Off.

LONE STAR CEMENT CORPORATION

Offices: ABILENE, TEX. · ALBANY, N. Y. · BETHLEHEM, PA. · BIRMINGHAM · BOSTON · CHICAGO · DALLAS · HOUSTON · INDIANAPOLIS
KANSAS CITY, MO. · LAKE CHARLES, LA. · NEW ORLEANS · NEW YORK · NORFOLK · RICHMOND · SEATTLE · WASHINGTON, D. C.

LONE STAR CEMENT, WITH ITS SUBSIDIARIES, IS ONE OF THE WORLD'S LARGEST CEMENT PRODUCERS. 21 MODERN MILLS. 47,900,000 BARRELS ANNUAL CAPACITY

NOVEMBER 1957

No. 5

Vol. 29

PROCEEDINGS VOL. 54

JOURNAL
OF THE
AMERICAN CONCRETE INSTITUTE

Published by the American Concrete Institute under the authority of its Board of Direction

President

WALTER H. PRICE

Vice-Presidents

DOUGLAS McHENRY — PHIL M. FERGUSON

Directors

WILLIAM H. ARMSTRONG — J. W. KELLY
ROBERT F. BLANKS — THOMAS B. KENNEDY
CLAYTON L. DAVIS — WALTER J. McCOY
HARRY C. DELZELL — RAYMOND C. REESE
BRUCE E. FOSTER — LEWIS H. TUTHILL
ROBERT C. JOHNSON — C. D. WAILES, JR.

Past Presidents

C. H. SCHOLER
CHARLES S. WHITNEY — FRANK KEREKES

Secretary-Treasurer
WILLIAM A. MAPLES

Technical Director
PAUL F. RICE

Managing Editor
ROBERT E. WILDE

Advertising Manager
CHARLES L. COUSINS

Manager, Publication Sales
ISABELLE DAVIS

Membership Secretary
EVELYN SCHLITZ

Cost per copy $1.50. Extra copies to ACI members $1.00.

Papers, committee reports, and other contributions to the **Proceedings** pages of this Journal, as submitted in furtherance of Institute objectives, are, if published, accepted on the sole responsibility of their authors. Institute authority attaches only to standards adopted as provided in the By-laws.

Advertising. See statement under "Alphabetical List of Advertisers," final page **News Letter section.**

Membership dues and Journal subscription rates. Members receive the Journal as one of the considerations of dues payment. Membership grades are: Individual (U. S., its possessions, and North and Central America), $15, Individual (all other foreign countries), $12, Corporation, $50, Contributing, $100, Junior, $7.50, Student, $5. Subscription prices are $12 per year, payable in advance ($15 per year outside North America and U. S. possessions). The Journal is issued monthly, July to June (the volume year being completed by title page, contents, indexes, and closing discussion in Part 2 of the subsequent December issue).

Bound volumes 1 to 52 of PROCEEDINGS of the AMERICAN CONCRETE INSTITUTE (1905 to 1955) are for sale as far as available at prices to be had on inquiry of the Secretary-Treasurer. Special prices apply for members ordering bound volumes in addition to the monthly Journal.

Address: American Concrete Institute, P.O. Box 4754, Redford Station, Detroit 19, Mich. **Copyright, 1957,** American Concrete Institute. Printed in U. S. A. Entered in the Post Office at Detroit, Mich., as mail of the second class under provisions of the Act of Mar. 3, 1879.

the ACI JOURNAL

is edited by the Secretary of the Technical Activities Committee under the direction of the Committee

WALTER J. McCOY
Chairman

WALTER H. PRICE
(ex officio)

WILLIAM A. MAPLES
Secretary

PHIL M. FERGUSON

CLYDE E. KESLER

BRYANT MATHER

MICHAEL V. PREGNOFF

L. H. TUTHILL

I. L. TYLER

WILLIAM A. MAPLES
Editor

ROBERT E. WILDE
Managing Editor

MARY K. HURD
Associate Editor

MARIAN PATTEN
Editorial Assistant

RUTH GABLE
Editorial Secretary

Coming next month in the JOURNAL

"Failures of Concrete Structures," by JACOB FELD, surveys concrete failures of the last half century in the United States, touching on legal aspects from the Code of Hammurabi through English common law with some observations on present code requirements. Mr. Feld will present his paper, with additional illustrations, at the forthcoming ACI convention in Chicago, Feb. 26, 1958.

●

"Design of Columns Controlled by Tension" by TUNG AU presents a new set of design charts for rectangular sections with symmetrical reinforcement and for square and circular sections with spiral reinforcement, subjected to combined bending and axial loads and controlled by tension.

●

Chapter 10 of the "Long-Time Study of Cement Performance in Concrete," reporting progress on the study of strength and elastic properties, will appear in the December issue. PAUL KLIEGER presents strength data through 3 years for laboratory mortar and concrete specimens made using the Long-Time Study cements. The report also presents information on the elastic properties of the concretes as determined by both static and dynamic means and pulse velocities as determined by the soniscope.

●

RENÉ E. WALTHER reports the findings of a test series on a large-scale model bridge (prestressed concrete) in his paper "Investigation of Multibeam Bridges." Empirical formulas for the relationship of stiffness properties and the influence of factors which affect the behavior of the structure are presented.

Manuscripts of papers, discussions, and reports should be sent in triplicate to:

Secretary, Technical Activities Committee
AMERICAN CONCRETE INSTITUTE
P. O. BOX 4754, REDFORD STATION, DETROIT 19, MICHIGAN

Winter Concreting Trends in Europe*

By E. G. SWENSON*

SYNOPSIS

Postwar labor and economic problems in Europe have led to governmental encouragement of winter construction. This has resulted in extensive, state-supported research on winter concreting, the progress of which is largely reflected in the papers presented by European authors at the RILEM Symposium on Winter Concreting in Copenhagen, February, 1956.

The primary consideration has been the reduction in costs of winter protection of green concrete concurrent with the achievement of better assurance of safety. Research has been directed toward methods of quantitative prediction of frost resistance and of minimum protection requirements. Methods of increasing frost resistance of green concrete have received attention.

Practical developments involve the refinement of existing methods of safe winter concreting, particularly the choice of building types most suitable for winter construction and the utilization of locally available materials.

INTRODUCTION

Because of the increasing importance of winter construction, the problems associated with winter concreting have been the subject of extensive investigation in recent years. Northern European countries appear to have taken a lead in the research field and there is much to be gained by a survey of developments in some of these countries.

The writer visited three Scandinavian countries and participated in a symposium on winter concreting held in Copenhagen, Denmark, in February, 1956. The following is a brief review of developments as gained from the papers and discussions at the symposium combined with observations of actual winter construction and talks with research workers and men on the job in Denmark, Sweden, and Norway.

The symposium on winter concreting was sponsored by the International Union of Testing and Research Laboratories for Materials and Structures, more commonly known as RILEM. The organization of the meeting was carried out by the Danish National Institute for Building Research; about 250 delegates from about 20 countries attended. Apart from small delegations from China and Japan, and one or two representatives each from Canada and the United States, the representation was predominantly northern European.

*Presented at the ACI 9th regional meeting, Montreal, P. Q., Oct. 25, 1956. Title No. 54-19 is a part of copyrighted JOURNAL OF THE AMERICAN CONCRETE INSTITUTE, V. 29, No. 5, Nov. 1957, *Proceedings* V. 54. Separate prints are available at 60 cents each. **Discussion** (copies in **triplicate**) should reach the Institute not later than Feb. 1, 1958. Address P. O. Box 4754, Redford Station, Detroit 19, Mich.

†Research Officer, Building Materials Section, Division of Building Research, National Research Council (Canada), Ottawa, Ont., Canada.

Most of the papers presented, therefore, reflected European thinking and practices.*

The purpose of this symposium was to coordinate and assess present knowledge of the theoretical and practical aspects of winter concreting. Four theoretical sessions dealt with: weather and climate in relation to winter concreting; laboratory experiments on winter concreting; the hardening of concrete as influenced by temperature; and the resistance of concrete to frost at early ages. The practical sessions dealt with high concrete quality in cold weather, and winter concreting on the job site.

ECONOMIC AND SOCIAL INFLUENCES

Since the war there has been in Europe an increasing trend to year-round construction which stems from the same causes as in Canada and the United States. Expansion in housing and other construction has been encouraged by government agencies through such methods as subsidization and preferential treatment. State controls are exercised through methods such as the building permit system. State financial support and direction have been provided in many European countries for research and development in winter construction. The Danish National Institute for Building Research has, through state support, carried out comprehensive research in the last 5 to 6 years on winter construction problems, including methods of concreting in cold weather. Similar support is provided in Sweden through the State Committee on Building Research, in Norway through the Building Research Institute, and in Finland through the State Institute of Technical Research. These agencies aid builders in organization and direction of winter work, and provide recommendations and specifications as well as research information.

As an example of the methods used to encourage winter construction, the Danish National Institute of Building Research, in its early program, provided monetary aid for additional expenditures by the contractor for exceptional weather conditions. The contractor received 5 kroner per effective man-day when the temperature at 8 a.m. was below −2 C (28.4 F), or if the precipitation in the course of the day was 5 mm (0.2 in.) or more. This aid was considered a contribution to extraordinary expenditure and measures, and also a compensation to the contractors for their pioneer work, reporting, etc.[2] Further inducement was provided by waiving certain building code requirements. The Danish institute also provided technical inspectors to give direction and advice.

Labor policy in these countries appears to have strongly supported winter construction in the interests of maintaining year-round employment. Observation of jobs and talks with builders indicated, however, that winter work, particularly in concreting, was usually discontinued during very cold periods, apparently for reasons of discomfort rather than danger of frost

*Six general reports were presented, one for each session, followed by some 25 supplementary papers. This writer was privileged to present the general report for the first session, on weather in relation to winter concreting. The complete record of the symposium, including discussions and summaries of conclusions for each session is available from the Danish National Institute of Building Research in Copenhagen.[1]

damage to concrete. This was rather well illustrated on the last 2 days of the symposium, when scheduled visits to winter concreting jobs in Denmark and southern Sweden were cancelled because work had stopped due to cold weather. Actual temperatures were reported to range from about 10 F down to −10 F during this period, which would not be considered extreme in Canada. Some such cases were due no doubt to lack of proper protective materials and equipment on the job.

Further incentive to winter concreting is provided by the need to utilize fully the comparatively expensive equipment kept on hand, and the skills of specialized labor which the builder wishes to retain. Quantity and variety of materials are also more readily available during the winter, as is the case in North America. Also certain operations can be carried out more advantageously in winter; for example, transportation on the site may be easier when the ground is frozen.

Further encouragement to winter concreting is provided by recent research which demonstrates that fresh concrete has a considerably higher resistance to frost damage than was previously thought, thus reducing the amount and cost of protection. Simpler methods of protection have also become available. Concrete placed in winter usually receives more uniform curing than in summer, a factor also to be considered.

Certain building types are better suited to winter concreting and advantage is taken of this fact; e.g., in Sweden cellular concrete is used extensively. In one common type of construction, precast cellular concrete slabs are placed as outside insulation and bonded to the inner monolithic, load-bearing concrete. During placing of the concrete, the cellular slabs serve as the outside formwork. In this type of construction protection requirements are considerably reduced.

Economic conditions in Europe naturally engender cost consciousness especially with regard to labor, and the methods developed reflect the urgency to minimize costs of protection. Research and practice therefore have focused on reducing the amount and time of protection and increasing the frost resistance of concrete. The degree to which European practice has developed in this direction appears limited, perhaps due largely to the usual reluctance to take practical risks on the basis of theory. The discrepancy between theory and practice in Europe would appear to be as great as in Canada.

ENVIRONMENTAL CONSIDERATIONS

Influence of the various elements of weather and climate on the cooling of concrete was treated in detail at the symposium in Copenhagen.[3,4,5] The conclusions establish that predictions based on temperature alone are inadequate. Factors of wind speed and radiation, in particular, can have proportionately as great an influence on heat losses as temperature difference alone. Local climatic factors may also modify the cooling of concrete considerably.

It was also emphasized that accurate prediction of cooling rates on any given job, taking all environmental factors into account, is extremely complicated and difficult to achieve. A reasonable estimation of conditions can be made, however, with the use of certain simplifying assumptions.

The practical, empirical methods already developed are based on outside temperatures only. Of special interest is the method proposed by the Danish National Institute for Building Research, which, for a given outside air temperature, provides for the calculation of the degree of protection required, the time when stripping of forms can be done, and the actual degree of hydration attained at any time.[6] Thus, the various internal factors are taken into account but only the external influence of temperature.

Field application of the principles and factors of heat loss in winter concreting appears as limited in Europe as in Canada and the United States,

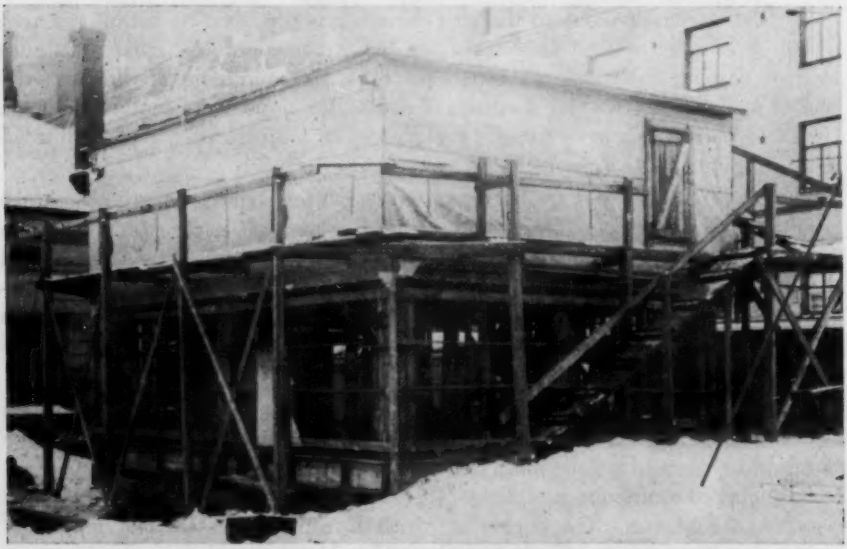


Fig. 1—Experimental house in Finland for research on winter construction; first floor enclosures removed

with the possible exception of large and important jobs such as, those of the Hydro-Electric Power Commission of Ontario and the United States Bureau of Reclamation. It is apparent, however, that in some countries an attempt is being made to utilize more fully climatic and weather data in winter concreting.

It was reported that in Holland the meteorological service is now consulted about special forecasts and climatic data for the building industry. Although its winter climate is not severe, it is capricious. "It will be impossible to indicate the periods by degrees of temperature because in Holland it is quite a different matter to have a day of minimum −5 C (23 F) with a depression coming from the west, or to have a minimum −5 C with a Siberian cold

coming from the east."[7] In Switzerland, as another example, account is taken of the increasing frequency of temperature drops below the freezing point with increasing altitude. In Finland and Norway, the continuous frost in most areas throughout a relatively long winter requires special protective measures. Minimum temperature records are used as a guide, and weather forecasts are studied to anticipate unexpected temperature drops. Special attention is given to rock temperatures. In general, protection requirements are based on temperature ranges, for example: −5 C (23 F) and up; between −5 C and −10 C (14 F); and below −10 C.

Winters in Denmark are considered extremely unpredictable. Below-freezing temperatures may come early or late, and the length of the winter may vary considerably. Many cycles of freezing and thawing occur, and it is almost always windy. Temperatures of 23 to 18 F, along with high humidities and high winds, can present a severe condition for construction work. Thus concreting is often discontinued at temperatures not considered too severe in North America.

In Finland an experimental house has been built to aid in the research on winter construction (Fig. 1). It is reported that studies will be made of weather factors as they influence heat losses under various forms of protection. Some data already available were reported at the symposium.[8]

TECHNOLOGY OF WINTER CONCRETE

Considerable progress has been made through laboratory experiments in the determination of the frost resistance of green concrete and the factors which influence this resistance. It is now possible to estimate the degree of hardening of concrete under various temperature conditions. Acceptable theories for concrete deterioration caused by freezing and for resistance to frost damage have been developed; these provide a much clearer understanding of the problems involved in winter concreting. These points were brought out clearly in the symposium papers.

Freezing of the plastic concrete before it has begun to set does no ultimate damage provided subsequent curing conditions are favorable. A certain "prehardening" time is required, however, before the green concrete can be subjected to below freezing temperatures without damage. This period ranges from 24 to 72 hr under normal conditions according to various investigators, and is influenced by proportioning, cement type, accelerators, and entrained air. In practice, considerations of safety require a 3-day period for normal concrete, but careful execution can permit a shorter prehardening period.

Frost damage during prehardening must be distinguished from delayed hardening caused by the slowing up of hydration at low temperatures. It was also made clear that there is no direct relation between frost resistance of green concrete and subsequent durability of the mature product subjected to cycles of freezing and thawing.

The application to field practice of the time-temperature function, based on the maturity concept, is generally successful, although some minor disagreement exists over the relative merits of the Saul-Nurse and the Rastrup methods. Considerable uncertainty exists, however, in their application to hardening at below freezing temperatures. It is possible, nevertheless, to estimate the degree of hardening of concrete under various conditions, and to determine the time when the concrete has attained frost resistance and when forms can safely be removed. As mentioned previously, the Danish National Institute for Building Research has incorporated this concept into an empirical field method which, for a given cement type, a given cement content, a given initial temperature, a given cooling factor which is based on heat of hydration, degree of insulation, and the geometry of the element, and for a given outside temperature, makes it possible to calculate the time required to attain a certain degree of hydration.[6] The Swedish Cement and Concrete Institute has conducted a program of tests to check this method.[9]

The basic research and theories of T. C. Powers on frost action and frost resistance of concrete have had great influence on European thinking and technology.[10] Air entrainment is now generally accepted, not only as a means of improving the durability of mature concrete, but as a means of increasing the frost resistance of fresh concrete. Extension of these concepts has been carried out by Danish and Swedish investigators, in particular, in an attempt to correlate experimental and field evidence. Methods of testing the extent of frost damage in concrete are still those which measure strength, dynamic modulus, and volume change.

Actual application of these principles and concepts to job work, as judged from limited observation of winter concrete work and talks with builders, appears to be limited. Extensive use is made of accelerators, entrained air, and high-early-strength cements. Considerable use is apparently made of the maturity function in estimating the strength development of winter concrete. In the opinion of the writer the practical field man in Europe is kept better informed of research developments and is perhaps better equipped to judge job situations, even though it may be in a qualitative way only, than his counterpart in North America. There is apparently closer collaboration between research and practice, probably for reasons of geography as well as through the obviously concerted efforts of research institutions and government agencies.

The development in the Soviet Union of the so-called "cold" concrete method is of special interest. Some discussion of this technique was given at the symposium but, unfortunately, there appears to be no complete translation into English of the published papers on the method. From available information, the following description can be given.[18] A mixture of calcium and sodium chlorides, up to 20 percent by weight of the mixing water, is incorporated in the concrete; the actual amount is determined by the outside temperature conditions. The concrete will harden satisfactorily at mix temperatures down to −10 C (14 F). It is possible, therefore, to use un-

heated materials for the mix, and protection can be disregarded or reduced to a minimum. It is necessary, however, to maintain the temperature, for the first 10 days, above the freezing point of the salt solution in the mix. It is claimed that in 90 days such concretes develop 90-100 percent of the strength of normally cured 28-day concrete. Bond strength with reinforcement is said to be high but frost resistance is lower than for normal concrete, and is lowered further with increasing water-cement ratio and when the concrete surface is exposed. Water impermeability of such concretes is said to be higher than for normal concrete. Added danger of corrosion of reinforcement is accentuated by thin concrete covering and by exposure to relative humidities between 60 and 90 percent. Care must be taken to obtain good compaction. It is claimed that costs of winter concreting can be considerably reduced by the use of this method as compared with the conventional "thermos" and heating methods.

The government sponsored investigation into winter concreting in Finland, carried out by the State Institute for Technical Research, included a study of methods employed and results achieved on a number of actual building sites, construction of an experimental house (already mentioned), and laboratory investigations. The various questions investigated have included: effectiveness of various methods and materials; relative costs; distribution of heat losses; suitability of building types; heat consumption; tightness of different enclosures; and the effect of various weather conditions. Preliminary results were reported at the symposium.[8]

PRIMARY METHODS OF PROTECTION

In Europe, monolithic and precast concrete find use in a wider range of building elements than in North America. Improved concrete technology has also resulted in the use of more slender elements. Consequently, extra emphasis has been given to methods of protection. Some countries provide specifications for winter concreting but these are admittedly treated in a qualitative way because of the variability of site conditions. Such specifications and recommendations, in general, cover: (a) methods of protection for various arbitrarily selected outside temperature ranges based on field experience; (b) methods of insulation and utilization of heat of hydration of the cement; (c) selection of suitable cement type; (d) use of admixtures; and (e) types of enclosures and methods of heating them.

As an example of detailed recommendations for minimum protective measures to be taken at different air temperatures within the first week after placing, the following is quoted from a Swedish source:[11]

"At temperatures:

+5 to 0 C (41 to 32 F)	When no $CaCl_2$ is added the water should be heated. When $CaCl_2$ is added no special measures are required, but the forms should be removed after approximately the same time as during the summer.

0 to −5 C (32 to 23 F)	The water should be heated and preferably $CaCl_2$ added. If $CaCl_2$ is added, the concrete may be placed without heating the water. The sand should be heated and frozen lumps thawed. The freshly placed concrete should be covered during the first night with tarpaulins or cardboard on a framework, or at least with cement bags.
−5 to −10 C (23 to 14 F)	The water should be heated and preferably $CaCl_2$ added. The sand should be heated and frozen lumps thawed. The freshly placed concrete should be insulated for 3 days with straw, straw mats, or similar insulating materials. Gaps in the story below should be covered and the temperature in the room under the concrete slab should be kept above 0 C (32 F) for 3 days.
Lower than −10 C (Below 14 F)	It would be preferable to postpone the placing of the concrete, but if the concrete must be placed the same measures as at temperatures between −5 and −10 C (23 to 14 F) should be taken. The insulation should not be removed until the temperature stays above −10 C (14 F)"

Practices involving standard materials

Storage protection and preheating of materials are generally practiced according to conventional methods. High-early-strength cement is widely used in winter concreting although it is reported to cost 50 to 70 percent more than normal portland cement.[11] High alumina cements, however, appear to be used only to a limited extent. It is recognized that in normal portland cement certain compositional factors are favorable: high tricalcium silicate and tricalcium aluminate, high silica, and low free lime. Low-heat-producing cements are usually avoided: slag, pozzolan and supersulfated cements.* Good practice requires the use of fresh cement since long storage appears to decrease the rate of heat development. Cement is not preheated, except indirectly through the usual dry storage protection. In some cases reduced relative humidities are obtained through slight heating by kerosene lamps.

The quality of the aggregates used appears to be generally based on the usual durability tests, but evaluation specifically based on frost resistance is being carried out, for instance, in Switzerland.[12] Here aggregate is classified as "generally suitable," "conditionally suitable," and "mostly unsuitable." Those considered unsuitable are high suction rocks and those containing clayey or humus-bearing ingredients because of high water absorption properties. Rounded particles are preferred because of their lower water requirements.

Aggregates are protected by storage in pits or silos. Preheating is done by heating truckloads in sheds or by steam heating through perforated pipes. An effort is made to control the steam heating of aggregate to avoid variation in the water-cement ratio. The low-pressure, mobile steam boiler is sometimes used. Ice crusting of aggregate is eliminated by various heating methods, including gas flames.

*Cements of this type produced in the United States have been used successfully during cold weather when protection measures have been taken which are recommended for portland cement.

Heating of the mixing water is the first step taken to raise the temperature of the concrete mix. For example, a recommended practice in Norway involves heating of water and aggregates for temperatures down to −5 C (23 F); preheating of all materials, and the insulation of forms for temperatures between −5 C and −10 C (14 F); and below −10 C, all precautions, including heated enclosures. Care is taken to provide controlled heating of the mixing water in order to eliminate variation in the initial concrete temperatures. The maximum temperature to which the ingredients may be heated is limited by the danger of premature hardening and varies with each cement. The Swedish Cement Association recommends a maximum temperature to which water or sand are to be heated, of 60 C (140 F) for normal cements, and 35 C (95 F) for rapid-hardening cements.[11] The sand rather than the coarse aggregate is heated because heated stone does not so rapidly provide equalization of heat, and excessive shrinkage may occur in the concrete. Sand braziers and hot metal plates are often used for heating the sand in the pile which, admittedly, may affect adversely the moisture condition of the material. Simple protection of aggregate piles by the use of tarpaulins is considered good economy since tarpaulins can be rented at low cost. Danish experience suggests that heating of aggregate is excessively expensive and should be avoided except where absolutely necessary.[2]

Admixtures

Acceleration of hardening with 1 to 2 percent additions of calcium chloride is frequently practiced. Entrained air is used primarily to reduce the water requirement and increase the workability of the mix. Its added value in increasing frost resistance is now being recognized. Favorable results using plasticiser admixtures are reported from Switzerland.[12] "Cold" concrete developed in the Soviet Union and mentioned earlier, in which high salt concentrations are used, appears applicable primarily to massive foundation-type elements. Alcohol and other anti-freeze agents are not generally used, although some instances were reported.[12]

Proportioning and mixing conditions

A recognized requirement for a winter concrete mix is a low water-cement ratio. This is variously accomplished by reducing the fine fraction in the sand, lowering the sand content of the mix, using rounded aggregate, or by admixtures such as the air-entraining ones to improve workability. Some practices require an increased cement content to obtain higher hydration heat.

Loss of heat during mixing is minimized by the usual method involving enclosure and organization for speed of operation. The initial temperature of the mix is maintained at some maximum depending on the quick-setting properties of the cement used. Initial mix temperatures as high as 50 C (122 F) have been used,[13] but the usual range is from 20 to 30 C (68-86 F).[14]

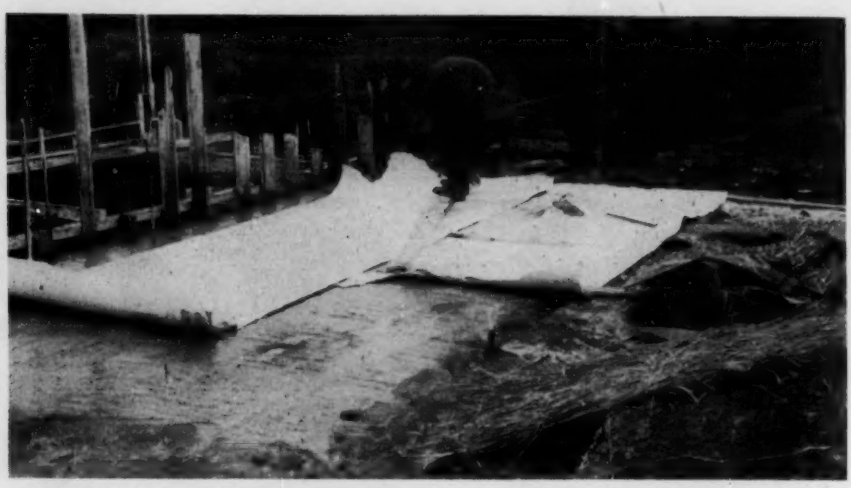


Fig. 2—Covering green concrete with knot pulp board and straw mats

Concrete bed, forms, and reinforcement

Protection against heat loss to the ground generally takes the form of covering excavations or preheating. One Norwegian practice consists of using a higher initial temperature of the mix in contact with rock, as well as preheating the rock.[14] In Norway and Switzerland, for example, special precautions are taken when preheating ground on slopes because of the effect on soil stability.[12] Formwork is designed to guard against moisture loss as well as heat loss. Jointed formwork is recommended, with form oil or chlorinated rubber varnish. Forms are often preheated with hot water or steam; the latter method is also used to remove ice crusts. Formwork is also preheated by electric heaters in Norway. Reinforcing is preheated by blow torch and flame thrower.

Transportation and placing

Heat loss during transportation and placing of concrete is kept to a minimum by organizing the work for maximum speed of handling. Protection in transport is usually achieved by short hauls, large loads, insulated containers, and protected conveyors. Formulas have been devised, for example in German directives, for calculating such heat losses.[15] Placing is done as rapidly as possible; compaction by vibration is preferred to hand tamping because of the low water-cement ratios used. Insulation and covering are provided immediately. Various methods are used to prevent direct contact of protective covering with the fresh concrete surface.

Insulated coverings

Choice of cover protection for fresh concrete is governed by cost and availability of materials, and also by local weather conditions. For example, paper covering is avoided when high winds are prevalent because of the risk

of tearing. Loose insulation cannot be used where rains and sleet are frequent, unless it is covered.

Straw, straw matting, and knot pulp are commonly used in Norway and Finland (Fig. 2). When wood products are available, as in most parts of the Scandinavian countries, cardboard and wood wool are used. The fire risk involved is considered. Materials such as glass wool, rock wool, and tarpaulins are less frequently used because of the higher cost. Glass wool is sometimes wrapped around slender elements. Empty cement bags are used for covering or plugging openings left by protruding reinforcement. Plywood panel formwork which can be used over again is quite common.

Special attention is given edges and corners where heat losses are highest due to greater surface in relation to volume. Form insulation is usually done with plywood paneling which provides an air space between it and the formwork (Fig. 3). Continuity of air gaps is interrupted to prevent heat loss by convection. The special problem of heat loss through protruding parts, such as reinforcing rods, is recognized and taken into account. Considerable data are available on the conductivities of these materials but, in nearly all cases, for the dry state only. Moisture loss from the newly placed concrete is counteracted by wide use of oiled paper and sealing compounds, presumably the same as American curing compounds. In many cases, however, reliance is placed on the insulation cover and formwork being left on as long as possible.

Enclosures and heating

Enclosures are generally considered too expensive to employ in most winter concrete work and are usually restricted to special structures and elements. Exceptions are structures where partial enclosure is already present in a building. Unless continuation of work is urgent, some recommendations suggest that concreting be stopped when temperatures fall below −10 C (14 F) or −15 C (5 F), rather than allow for the use of full enclosure as in North America.

Choice of materials for heated enclosures is again governed by cost and availability. In the Scandinavian countries, paper and cardboard are fre-

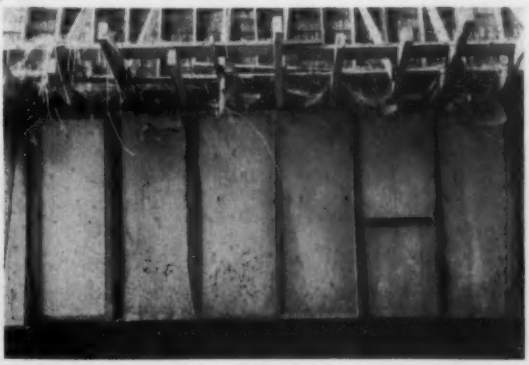


Fig. 3—Framed plywood covering. Note protruding formwork

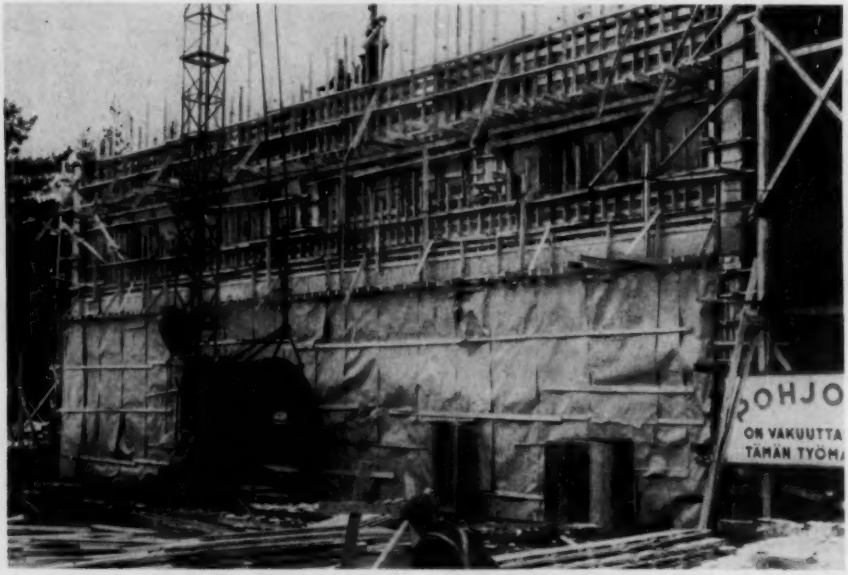


Fig. 4—Enclosure of knot pulp board fastened with waste board on skeleton framework

quently nailed over waste wood framing (Fig. 4). Wood slabs are also in common use. In Finland paper is used for covering windows in a building. In countries where wood products are limited, canvas and various other readily available materials are employed. Steel tube framing is sometimes used where canvas covered enclosures are employed.

Certain features in the design of enclosures are favored because of convenience and low cost. Enclosures are restricted to the smallest volume possible to conserve heat. Small movable shelters are used where continuity of operation make it possible (Fig. 5). Special attention is given to protruding parts, scaffolding arrangement, elimination of convection, and arrangement for temporary openings. Overlapping canvas hoods are sometimes employed.

Sources of heat include wood and coke burners, oil burners, electric heaters, and mobile steam boilers such as the Swedish Osby, or the "Jokke 2" oil heater (Fig. 6). The latter two types are noteworthy for the rapidity with which they can develop steam pressure. Special attention is given to uniform distribution of heat sources because of the danger of local overheating, particularly at edges and corners. Where hot air is used, as is common in Switzerland, pans of water or similar devices are used to prevent excessive drying of the concrete.

As far as possible the same heat source is used for heating aggregate and water as for heating the concrete. Centralized heating systems are used extensively. These consist of boiler plants for high or low pressure steam heating. Oil heating is becoming common but waste wood materials are still

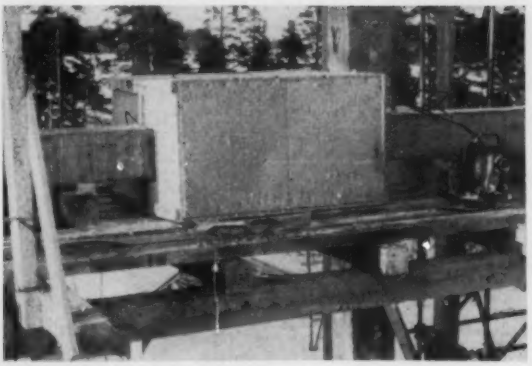


Fig. 5—Portable wallboard enclosure for joint of a prefabricated beam, heated by electric bulbs

the principal fuel. Common procedure in Switzerland is to place perforated steam pipes in stockpiles or to place heating grills under them. Infra-red radiation heaters have been employed successfully. Electro-curing has been developed and used successfully in Switzerland, but the higher cost has prevented any extensive use of this method. Radiation heating by placing heating coils in concrete ceiling slabs was reported.[8]

Inspection and control

Inspection and control of operations appear to be of a more positive type in European practice than is usually the case in North America. For example, some Swiss recommendations require daily casting of test specimens, part of which are stored under normal conditions, and part under the same exposure as the structural elements.[12] A consulting engineer in Norway showed the writer a method of control which he followed on his jobs. Flexural and compressive strengths were taken on specimens from the job concrete and plotted during the progress of the job. By agreement with the contractor, any concrete below a specified quality was not paid for. The writer was told that in Sweden a contractor is held legally responsible for a building for 2 years.

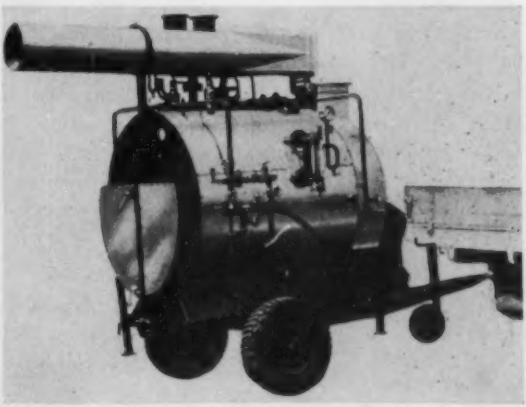


Fig. 6—A mobile steam boiler used on winter construction jobs

JOB PRACTICES

Certain site practices are being recognized as aids to more efficient protection during winter concreting, i.e., winter work techniques are being developed as distinct from conventional practices.

Types of structures

Considerable attention is now being given in Europe to the suitability of structures for winter construction. In Finland buildings with masonry supporting walls and reinforced concrete floors are increasingly not considered for winter construction.[16] This is largely because the "mixed character" of the work involved can complicate protective measures. Buildings with supporting concrete partition walls and reinforced concrete floors are simpler and easier to rationalize from the point of view of winter construction and protection. Reinforced skeleton frame structures are also favored in Finland, with brickwork or precast wall sections put up under more favorable conditions.

A large proportion of apartment buildings in Sweden are built with exterior concrete walls having outside insulation of cellular concrete. Protection for such structures is relatively simple since the exterior walls, apart from window and door openings, are already insulated. A variation of this method is developing in Finland where the sliding-form technique is used. It is considered particularly suited to winter construction.

The use of prefabricated concrete elements is used widely in winter construction work in Europe, particularly in the Soviet Union. The advantages are evident, especially for large structures. Care has to be taken, however, in protecting the necessary grouting operations.

General organization

Relatively mild and variable winters in many parts of Europe permit planning of construction so that concreting can be carried out during the most favorable weather. This is done to avoid expensive enclosures and heating. The starting date of construction is an important factor in these cases. Advance arrangements for materials can therefore be made.

The actual concreting itself is usually begun in the morning in order to finish a particular section before the onset of lower night temperatures. It is reported that preliminary "drills" of construction crews have shown good results in speeding up operations, such as transportation and placing of the concrete, and providing covering. Speed is also important to avoid later delay in permitting follow-up work.

Scaffolding is arranged to minimize interference with protective coverings. The installation and removal of forms is considered in connection with speed of operation. Organization for rapid removal of snow is also taken into account. A definite effort is made to plan reasonably comfortable conditions for workmen. This applies to eating and clean-up quarters as well as working

places. Government agencies have encouraged manufacturers to design clothing particularly suited to winter construction work.

Considerable use is made of the "Hico" system for supporting floor slab and wall forms. This involves the use of adjustable steel girders resting on wall forms and bracing, permitting placing of a floor slab without interfering with the area below which can then be used for various job operations. Basement areas are usually used for storage purposes as well as for small jobs.

As far as is possible heat sources for enclosures are used which can be employed for other purposes. Steam can be used to heat living and office quarters, for example. Wood-burning, mobile boilers, called locomobiles, are used widely since they are available as cheap surplus from agricultural agencies following electrification of rural areas in parts of Scandinavia.

Forecast weather data are utilized in conjunction with long term average minimum temperatures. On most of the larger jobs, thermometers and thermocouples are placed in the concrete and a record is kept of the progress of cooling. Extra covering material is usually provided in case of sudden drops in temperature.

Ready-mixed concrete is considered an important factor in winter concreting in Denmark.[17] Provision for storage and preheating of materials on the job is eliminated. The thawing of snow and ice around formwork can be done by flame throwers. This procedure is particularly suited to conditions where the placed concrete is sufficiently protected by unheated covering.

CONCLUSIONS

In Europe, special efforts are made to encourage and promote winter construction. Research on winter concreting has been pursued intensively with the help of state funds, particularly in the Scandinavian countries.

The primary concern for added costs of winter work has directed investigations into developing methods for increasing the frost resistance of concrete and determining the minimum protection requirements. Progress has been made in developing quantitative methods for predicting the maturity of the concrete, taking into account the material properties and the geometry of the elements, but only for variations in outside temperature conditions. The influences of the different climatic elements and factors however, have received little attention. The development of the "cold" concrete technique in the Soviet Union is of special interest.

A direct consequence of the increasing trend to winter construction is the growing tendency to choose those types of structures most amenable to winter protection. This is reflected in the wider use of prefabricated elements and the Swedish techniques involving cellular concretes.

It is evident, however, that progress in the application of technical advances to field practice is retarded by conservative attitudes in the building industry, a situation similar to that in North America.

ACKNOWLEDGMENTS

This paper is a contribution from the Division of Building Research, National Research Council, Canada, and is published with the approval of the director. Fig. 1, 2, 3, and 4 were supplied through the courtesy of A. Nykänen, State Institute of Technical Research, Helsinki, Finland. B. Kelopuu, civil engineer, Helsinki, provided Fig. 5, and Fig. 6 was supplied by S. G. Bergstrom, Swedish Cement and Concrete Institute, Stockholm Sweden.

REFERENCES

1. *Proceedings*, RILEM Symposium on Winter Concreting Theory and Practice, Copenhagen, Feb. 1956. Issued as a special report of the Danish National Institute of Building Research, Copenhagen. (Many of the references following were papers from the symposium.)

2. Plum, Niels M., "Winter Construction in Denmark," an address to OEEC delegation, Danish National Institute of Building Research, Copenhagen, Feb. 1951, 12 pp.

3. Swenson, E. G., "Weather in Relation to Winter Concreting," RILEM Symposium on Winter Concreting, Copenhagen, Feb. 1956.

4. Vinberg, A. H., "Temperature Variations in Sweden of Importance for Tests of Freezing Resistance," RILEM Symposium on Winter Concreting, Copenhagen, Feb. 1956.

5. Jessing, J., "Influence of Weather Factors on Heat Energy Level—A Case of Calculations," RILEM Symposium on Winter Concreting, Copenhagen, Feb. 1956.

6. Nerenst, P., Rastrup, E., and Idorn, G. M., "Betonstøbning om Vinteren," *Direction* No. 17, Danish National Institute of Building Research, Copenhagen, 1953.

7. Buitink, J. G., and Trouw, J. M. L., "Starting Winter Concreting in Holland," RILEM Symposium on Winter Concreting, Copenhagen, Feb. 1956.

8. Nykanen, A., "Experimental House as an Aid in Winter Concreting Research," RILEM Symposium on Winter Concreting, Copenhagen, Feb. 1956.

9. Möller, G., "Tests of Resistance of Concrete to Early Frost Action," RILEM Symposium on Winter Concreting, Copenhagen, Feb. 1956.

10. Powers, T. C., "Resistance of Concrete to Frost at Early Ages," RILEM Symposium on Winter Concreting, Copenhagen, Feb. 1956.

11. Naslund, B., "Winter Construction," *Brochure* No. 3, State Committee for Building Research, Stockholm, 1952. Also available as N.R.C. TT-583.

12. Voellmy, A., "High Concrete Quality in Cold Weather," RILEM Symposium on Winter Concreting, Copenhagen, Feb. 1956.

13. Yokomichi, H., "Influence of High Temperatures of Mixing Water," RILEM Symposium on Winter Concreting, Copenhagen, Feb. 1956.

14. Grøner, C. F., "Setting Temperatures in Concrete," RILEM Symposium on Winter Concreting, Copenhagen, Feb. 1956.

15. Kleinlogel, A., *Winterarbeiten im Beton und Stahlbetonbau*, Wilhelm Ernst und Sohn, Berlin, Revised Edition, 1953, 131 pp.

16. Kelopuu, B., "Winter Concreting on the Job Site," RILEM Symposium on Winter Concreting, Copenhagen, Feb. 1956.

17. Jorgensen, F., "Winter Concreting with Ready Mixed Concrete," RILEM Symposium on Winter Concreting, Copenhagen, Feb. 1956.

18. Mironov, A., and Krylov, B. A., "Primenenic betonov s dobavkami khloristykh solei v zimnikh usloviiakh (Calcium and Sodium Chlorides as Cement Additives in Winter Concreting)," Academii Nauk SSSR, Inst. Tekh.-ekon. Info., Moscow, 1956.

Discussion of this paper should reach ACI headquarters in triplicate by Feb. 1, 1958, for publication in the June 1958 JOURNAL.

Title No. 54-20

Variation of Mortar and Concrete Properties with Temperature*

By J. C. SAEMANN† and G. W. WASHA‡

SYNOPSIS

Effects of temperature upon strength, stiffness, and toughness of mortars and concretes are given. Two mortars and two concretes varying in cement content, and one lightweight concrete were used in the investigation. Mortar cubes, briquets, cylinders, beams, and concrete cylinders were tested after a 24-hr preconditioning treatment at test temperatures which varied between −70 and 450 F.

Test results at subnormal temperature showed that mortar and concrete properties generally increased as the temperature decreased. Test results at elevated temperatures were not as consistent but in general the properties first decreased as the temperature increased, then increased, and finally decreased. At 450 F the strengths of the mortars and concretes were about equal to those at room temperature, but the moduli of elasticity were considerably lower.

INTRODUCTION

Portland cement concrete is used in structures subjected to widely varying temperatures. Concrete has been used successfully when exposed for long periods of time to temperatures considerably above and below room temperature. In most cases such concrete is mixed, placed, and cured under reasonably standard conditions.

This project was undertaken to determine strength, stiffness, and toughness of mortars and concretes as the test temperature varied between −70 and 450 F. The mortars and concretes were moist cured at normal room temperature 14 days, then were stored in air at 70 F and 50 percent relative humidity for 13 days, and then held at test temperature for 24 hr before test.

Ordinarily, concrete used at temperatures considerably above or below 70 F is proportioned on the basis of tests performed at room temperature. It is felt that concrete subjected to temperatures other than room temperature should be proportioned on the basis of data such as presented herein. A natural extension of this work would include results for concrete subjected to different exposure conditions, for concrete cured in different ways, and for concrete containing other materials.

*Received by the Institute Jan. 21, 1957. Title No. 54-20 is a part of copyrighted JOURNAL OF THE AMERICAN CONCRETE INSTITUTE, V. 29, No. 5, Nov. 1957, *Proceedings* V. 54. Separate prints are available at 50 cents each. **Discussion** (copies in **triplicate**) should reach the Institute not later than Feb. 1, 1958. Address P. O. Box 4754, Redford Station, Detroit 19, Mich.

†Associate Professor of Mechanics, University of Wisconsin, Madison Wis.

‡Member American Concrete Institute, Professor of Mechanics, University of Wisconsin, Madison, Wis.

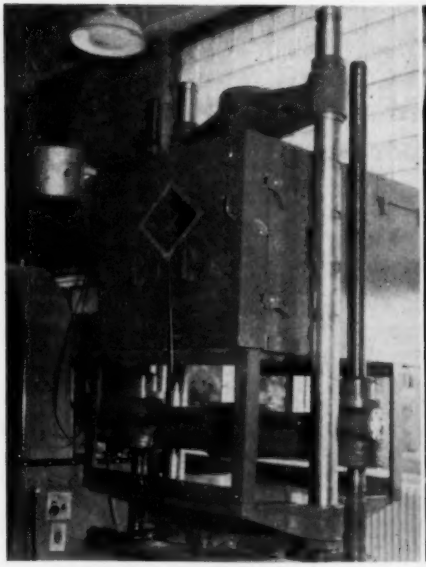


Fig. 1—Insulated box for mortar tests

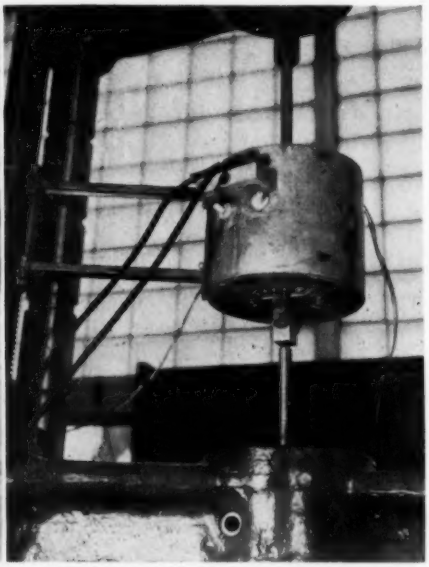


Fig. 2—Electric oven for mortar tests

Tests on mortars at temperatures between −70 and 300 F were performed during the summer of 1955. Tests on concretes at temperatures between 0 and 450 F and an extension of mortar tests at temperatures from 300 to 450 F, along with some check testing, were performed during the summer of 1956.

MATERIALS, MIXING, AND CASTING

Aggregates

The sand was obtained locally in Madison, Wis. Most material retained on a No. 16 sieve was calcareous, and most material passing a No. 16 sieve was siliceous. Physical properties of the sand are given in Table 1. All sand was air dried, sieved into six size fractions, and then recombined according to the indicated precentages to insure uniform gradation.

The gravel obtained in Madison, Wis., was predominantly calcareous. Physical properties of the gravel are given in Table 1. All gravel was air dried, sieved into two size fractions, and then recombined according to the indicated percentages.

Kenlite, an expanded shale, was obtained from Kentucky Light Aggregates, Inc. Physical properties of the blend used—80 percent fine and 20 percent coarse—are given in Table 1. All Kenlite was air dried and uniformly mixed before batching.

Cement

A local Type I portland cement was used. Results of physical acceptance tests are given in Table 2. Results for a second shipment of the same brand which was used in the program extension 1 year later are also given.

Mix proportions

Dry weight proportions of the two mortar mixes and three concrete mixes are given in Table 3. The water-cement ratios listed are based on net water, with the exception of Mix 3C containing Kenlite, where the water-cement ratio is based on total water, i.e., net water

TABLE 1—PROPERTIES OF AGGREGATES

Property	Madison sand	Madison gravel	Sand and gravel		Kenlite
			Combination No. 1*	Co nbination No. 2†	
Specific weight, lb per cu ft	117.6	103.3	126.7	129.3	63.9
Absorption, percent	0.3	1.5			
Sieve analysis, percent coarser than sieve:					
1 in.	0.0	0.0	0.0	0.0	0.0
¾ in.	0.0	1.8	1.1	1.0	0.0
½ in.	0.0	31.6	20.1	17.5	0.0
⅜ in.	0.0	56.0	35.6	31.0	0.0
No. 4	3.9	96.8	63.0	55.3	16.2
No. 8	16.6	100.0	69.6	63.8	32.6
No. 16	27.6	100.0	73.6	68.7	55.9
No. 30	39.8	100.0	7ᴄ.1	74.2	73.0
No. 50	71.7	100.0	89.7	88.4	83.2
No. 100	95.0	100.0	98.2	98.8	89.4
Fineness modulus	2.55	6.55	5.09	4.81	3.50

*Used in Mix 1 C.
†Used in Mix 2 C.

plus water absorbed by air-dry aggregate. These water-cement ratios were maintained constant throughout the program. As a result mortar consistency as measured by the flow table and concrete consistency as measured by the slump test varied slightly for different batches. The results listed in Table 3 are average values.

Manufacture

All mortar batches were mixed by hand until they were uniform. All concrete batches were mixed in a rotating drum mixer for 5 min after all materials had been added.

Immediately after filling, all molds were covered with wet canvas. One day after molding the specimens were stripped and placed in a moist closet. Following 13 days moist-closet curing at 77 F they were stored in air at 70 F and 50 percent relative humidity.

TEMPERATURE PRECONDITIONING

Mortar specimens

Mortar strength and stiffness tests at temperatures between −70 and 300 F were performed in an insulated box which was placed in the testing machine (Fig. 1). Thermostatically controlled electrical heating coils maintained desired temperatures above room temperature. The heated air was circulated continuously by a small fan. Temperatures below 70 F were obtained by circulating air through a compartment containing dry ice. Specimens were placed in this insulated box 24 hr before testing, during which time the test temperature was maintained.

Mortar strength tests at temperatures between 300 and 450 F were performed in an electric oven which was placed in the testing machine (Fig. 2). Temperatures were controlled by an on-off temperature controller. Specimens were preheated in a gas oven at test temperature for 24 hr and then placed in the heated electric oven 10 min before testing.

Concrete specimens

Concrete strength and stiffness tests were performed at temperatures between 0 and 450 F. An electric oven controlled by an on-off temperature controller was used to obtain temperatures above 70 F (Fig. 3). Specimens were preheated in a gas oven at test temperature for 24 hr and placed in the heated electric oven 40 min before testing. When test temperatures were

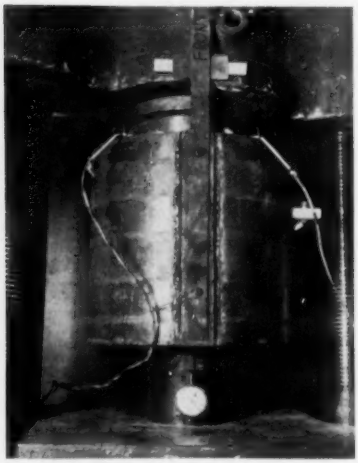


Fig. 3—Electric oven for concrete tests

below 70 F, specimens were precooled in a refrigerator for 24 hr before testing. Shortly before removing the specimens from the refrigerator, they were wrapped with a 2 in. thick glass fiber insulation blanket which helped maintain the temperature during the test. Tests were performed within 2 min after removal of the specimens from the refrigerator. During this period the temperature rise at the surface of the concrete specimens amounted to about 5 F for those tested at 0 F and 1 F for those tested at 50 F.

TEST METHODS

Mortar tests

Three 2-in. cubes were tested per variable to determine the compressive strength. Three standard mortar briquets were tested per variable to determine the tensile strength.

Three cylinders, 3 in. in diameter and 6 in. high, were tested per variable to determine compressive strength and modulus of elasticity in compression. All cylinders were capped with neat cement paste. Change in length over 2 in. was obtained from readings of SR-4 gages cemented to the inner and outer surfaces of the curved portion of two calibrated, aluminum, U-shaped clips which were attached to opposite sides of the cylinders with springs (Fig. 4). The points of the clips rested in drilled holes in brass plugs which were attached to the cylinders with bakelite cement. The secant modulus of elasticity was determined at ⅓ ultimate load.

Three 2 x 2 x 16-in. beams were tested per variable to determine modulus of rupture, modulus of elasticity in bending, and energy of rupture in bending. The beams were tested, molded side up, with third point loading on a 15-in. span. Center deflections were measured with a dial gage (Fig. 5). The modulus of elasticity was determined at ⅓ ultimate load. The energy of rupture was determined from the area under the load-deflection curve.

Concrete tests

Three cylinders, 6 in. in diameter and 12 in. high, were tested per variable to determine compressive strength and modulus of elasticity in compression. All cylinders were capped with neat cement paste. Some cracking in the cement caps occurred, especially on those specimens tested at the higher temperatures, but the caps adhered to the cylinders. Change in length over 6 in. was obtained from two dial gages. The gages were attached to a C-shaped ring

TABLE 2—PROPERTIES OF PORTLAND CEMENT

Property	Original program	Program extension
Compressive strength, 7 days	2380 psi	2665 psi
28 days	3680 psi	4460 psi
Tensile strength, 7 days	430 psi	335 psi
28 days	490 psi	445 psi
Soundness, autoclave expansion	0.035 percent	0.078 percent
Time of set, initial	3 hr 45 min	3 hr
final	6 hr 30 min	5 hr 45 min
Fineness, Blaine air permeability apparatus	3120 sq cm per g	2980 sq cm per g

TABLE 3—PROPERTIES OF MORTARS AND CONCRETES

	Mortar		Concrete		
Mix No.	1M	2M	1C	2C	3C
Aggregate	Sand	Sand	Sand and gravel	Sand and gravel	Kenlite
Proportions by weight	1:2.00	1:4.50	1:2.00:3.50	1:4.35:5.40	1:2.72
W/C ratio	0.48	0.84	0.48	0.84	0.81*
Specific weight (wet), lb per cu ft	140.7	139.0	151.9	149.1	109.5
Flow, percent	105	105			
Slump, in.			3	3	2

*Total water-cement ratio.

by means of extension rods in order to have the gages outside of the oven. Extension rods attached to a second ring actuated the gages (Fig. 6). Both rings were fastened to the cylinders with set screws. Test temperatures were maintained for 40 min before testing so that all parts used in measuring change in length would reach equilibrium conditions. The secant modulus of elasticity was determined at ⅓ ultimate load.

Moisture content at test

Portions of broken specimens were selected immediately following testing for moisture content determination. For mortars, all samples were taken from the cubes, and for concretes, all samples were taken from the cylinders. Samples were dried in a gas oven at 220 F until equilibrium was essentially reached.

Thermal coefficient of linear expansion

Two 2 x 2 x 11-in. prisms with end studs were used to determine the thermal coefficient of expansion. After the prisms had come to essential equilibrium with air at 70 F and 50 percent

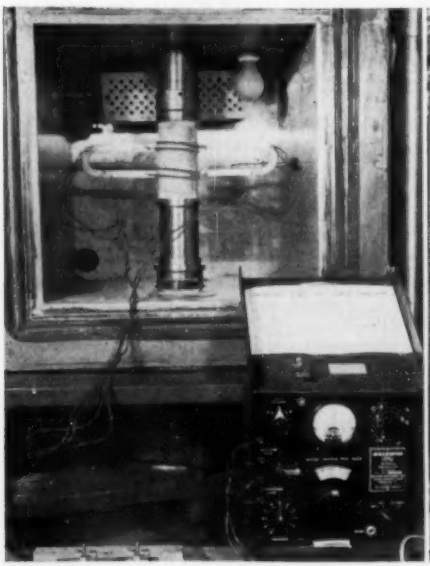


Fig. 4—Strain measuring equipment for compression test of mortar cylinders

Fig. 5—Cross bending test apparatus

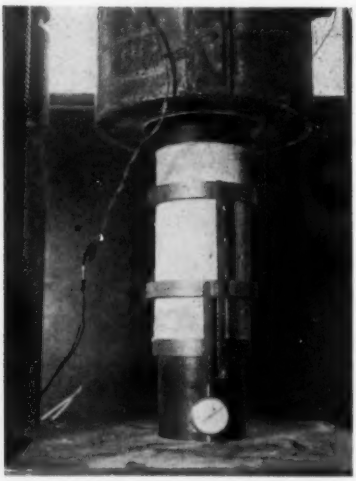


Fig. 6—Strain measuring equipment for compression test of concrete cylinders

relative humidity, they were wrapped in paper and coated with paraffin to prevent moisture change during testing. The change in length accompanying a change in temperature from 70 to 0 F was used in computing the thermal coefficient.

DISCUSSION OF RESULTS

Moisture content

The moisture content of mortars and concretes decreased as the test temperature increased as shown in Fig. 7. The small positive values at 200 to 250 F indicate that moisture was still present in the test specimen after the 24-hr temperature preconditioning. This could be removed by continued drying at 220 F. Negative moisture contents for specimens made with sand and gravel aggregates and tested at temperatures above 300 F were due to the reabsorption of water and/or carbonation in the gas drying ovens operating at 220 F. Temperatures of 400 F and above were necessary to produce negative moisture contents in concrete containing Kenlite aggregate.

Moisture content at test affects concrete strength. After similar preliminary curing conditions the compressive strength of dry concrete may be 20 to 40 percent greater than that of saturated concrete tested at the same temperature. Tensile and transverse strengths of concrete are usually reduced by drying. In this report no attempt was made to separate the changes in strength due to moisture variation from those due to temperature variation.

Compressive strength

Variations in compressive strength of mortars at temperatures between −70 and 450 F are shown in Fig. 8. Compressive strength increased with decrease in test temperature below room temperature. At −70 F Mix 1M was about 60 percent stronger than at room temperature, and Mix 2M about 100 percent stronger. As test temperature increased above room temperature, compressive strengths decreased to minimum values at about 150 to 200 F. Strengths were reduced 30 and 20 percent compared to room temperature values for Mixes 1M and 2M, respectively. Further increase in temperature to about 400 F brought about increases in strength to just above room temperature strength values in most cases. Strengths tended to decrease beyond 400 F.

Similar trends for compressive strength of concretes are evident in Fig. 9. At 0 F strengths were increased 40 percent compared to strengths at room temperature for Mixes 1C and 3C, and 70 percent for Mix 2C. At temperatures

between 200 and 250 F minimum values were reached, about 10 percent lower than room temperature values. Between 300 and 350 F results about 10 percent higher than room temperature values were obtained. Strengths tended to decrease beyond 400 F.

Higher temperatures would have been desirable in order to determine at what temperature strengths begin to decline rapidly. However, 450 F was about the maximum operating temperature for much of the equipment used in this program.

Tensile strength

Fig. 8 shows variation in tensile strength of mortars with temperatures between −70 and 450 F. As test temperatures decreased below room temperatures, tensile strengths increased. At −70 F strengths were about 30 percent higher than values at room temperature. As test temperature increased above room temperature, strengths decreased to minimum values. At 150 F

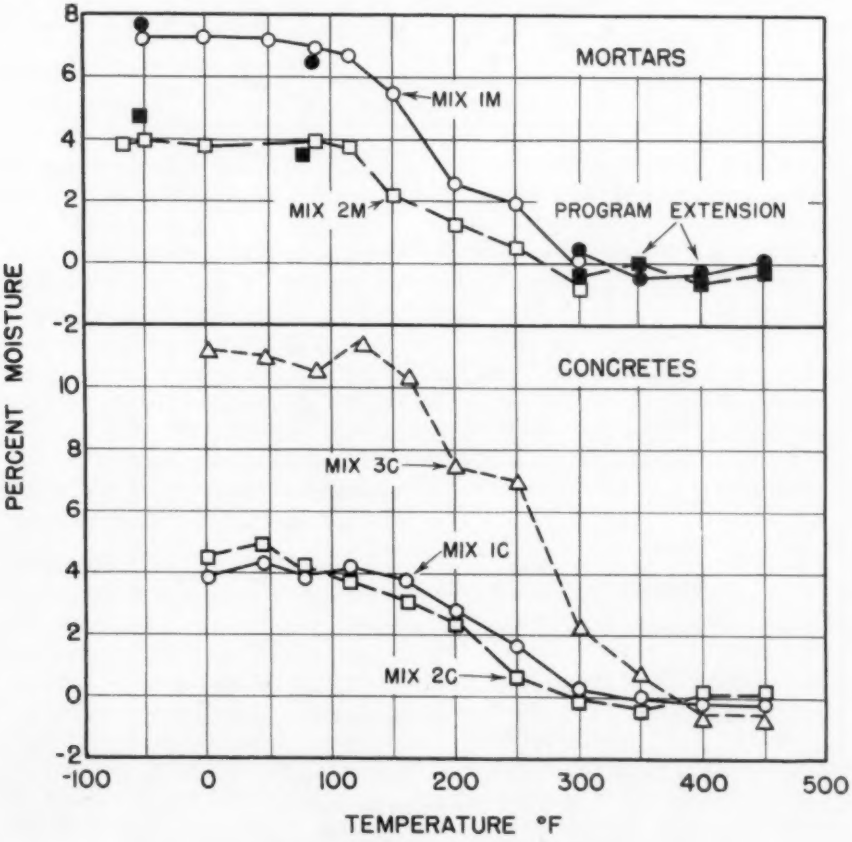


Fig. 7—Moisture content at test

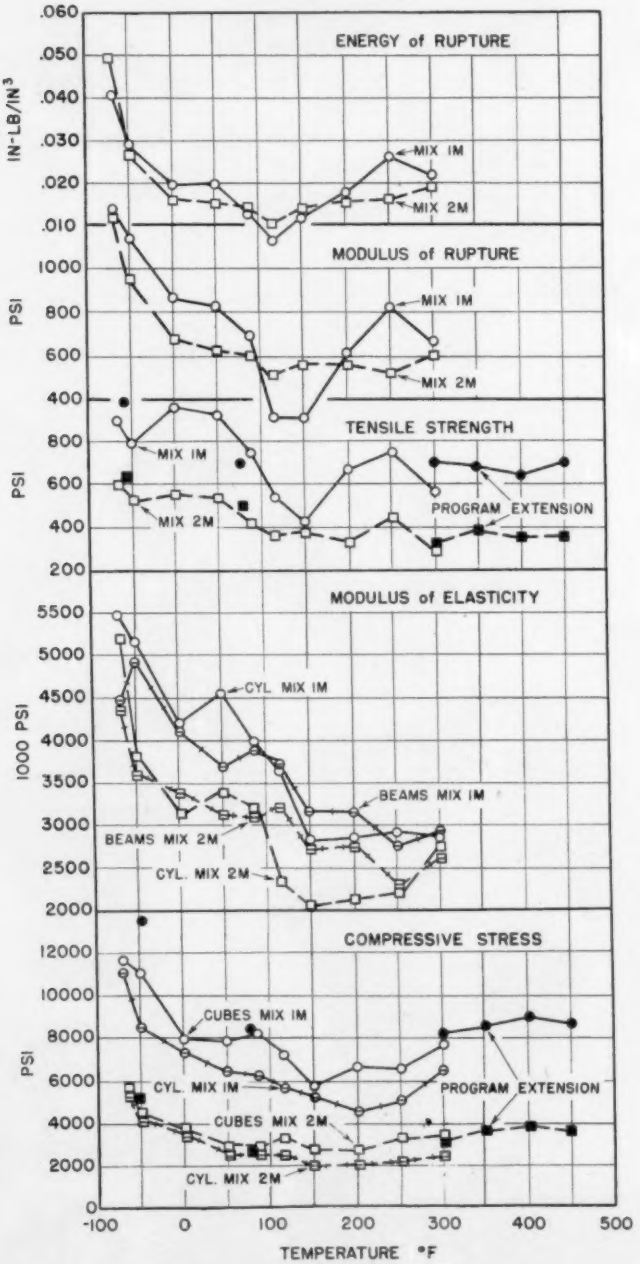


Fig. 8—Variation of mortar properties with testing temperature

the strength of Mix 1M was 40 percent lower than at room temperature, and at 200 F, Mix 2M was 20 percent lower. Further increase in temperature to about 250 F increased strengths to about room temperature values.

Transverse strength

Fig. 8 shows variation in modulus of rupture of mortars with temperatures between −70 and 300 F. The transverse strength increased with decrease in temperature below room temperature. At −70 F the modulus of rupture of Mix 1M was 80 percent higher than at room temperature, and that of Mix 2M, 100 percent higher. Increases in temperature beyond room temperature caused transverse strength to decrease to minimum values at about 100 to 150 F. Moduli of rupture were reduced 50 and 10 percent compared to room temperature values for Mixes 1M and 2M, respectively. Further increase in temperature produced a slight increase in transverse strength of Mix 2M, to about the room temperature value. Mix 1M showed a large increase in modulus of rupture with increase in temperature to 250 F, the value at 250 F being 20 percent higher than at room temperature.

Stiffness

Variations in modulus of elasticity of mortars at temperatures between −70 and 300 F are shown in Fig. 8. Stiffness increased with decrease in test temperature below room temperature. At −70 F the modulus of elasticity of Mix 1M was about 20 percent higher than at room temperature, and for Mix 2M, about 50 percent higher. As test temperature increased beyond room temperature, stiffness generally decreased. At 300 F the moduli of elasticity were about 20 percent lower than room temperature values.

Similar trends for stiffness of concretes are evident in Fig. 9. At 0 F moduli of elasticity were about 10 percent higher than at room temperature. At temperatures between 200 and 250 F values about 10 percent lower than room temperature values were obtained for Mix 1C and about 25 percent lower for Mixes 2C and 3C. Between 300 and 350 F values were approximately equal to room temperature values for Mixes 1C and 2C, and about 20 percent lower than the room temperature value for Mix 3C. Further increase in temperature brought about a decrease in stiffness.

Toughness

Changes in energy of rupture of mortars with temperatures between −70 and 300 F are shown in Fig. 8. Toughness increased with decrease in temperature below room temperature. At −70 F the energy of rupture of Mix 1M was about three times that at room temperature, and about 3.5 times that at room temperature for Mix 2M. As test temperature increased beyond room temperature, toughness decreased to minimum values at about 100 F. Energy of rupture was reduced 50 and 25 percent compared to room temperature values for Mixes 1M and 2M, respectively. Further increase in temperature to about 250 or 300 F brought about increases in toughness, 100 precent increase above the room temperature value for Mix 1M and 40 percent for Mix 2M.

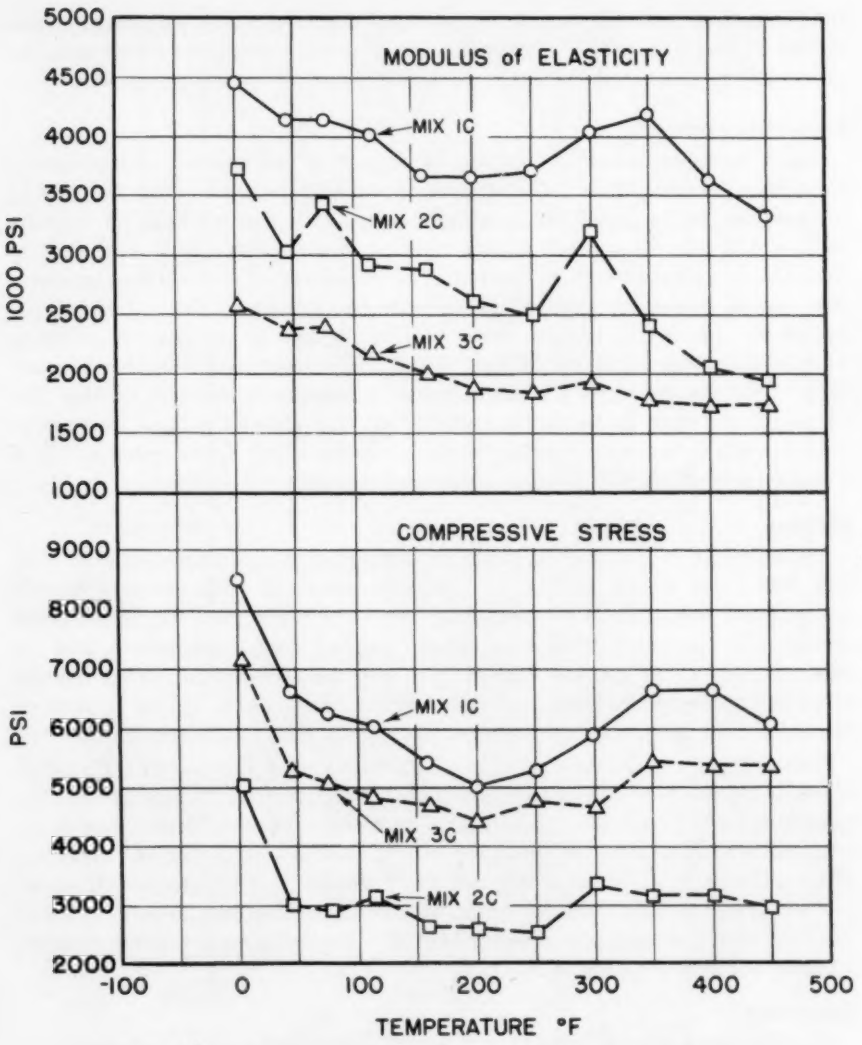


Fig. 9—Variation of concrete properties with testing temperature

Thermal coefficient of linear expansion

The thermal coefficients of expansion per deg F for the various mixes were:

Mix 1M	5.8×10^{-6}
Mix 2M	5.3×10^{-6}
Mix 1C	4.4×10^{-6}
Mix 2C	4.4×10^{-6}
Mix 3C	3.9×10^{-6}

CONCLUSIONS

1. After 24-hr preconditioning at test temperature, strength, stiffness, and toughness of mortars, and strength and stiffness of concretes generally increased as the test temperature decreased below 70 F.

2. In general, as test temperatures increased above 70 F the properties first decreased, then increased, and finally decreased.

3. At about 450 F the strengths of the mortars and concretes were about equal to those at 70 F, but the moduli of elasticity were considerably lower.

4. Sand-and-gravel concrete and expanded-shale concrete responded similarly to variations in test temperature.

ACKNOWLEDGMENTS

All tests were made in the materials testing laboratory of the University of Wisconsin. The program was financially supported jointly by the Univeristy of Wisconsin Engineering Experiment Station and the research funds of the mechanics department of the University of Wisconsin. Thanks are due to L. M. Basford, M. C. Blake, T. E. DeWitte, R. D. Donohoo, R. J. Leistikow, and R. E. Sherrer for their help in testing, and to W. C. Young for his assistance in designing strain-measuring equipment.

REFERENCES

1. *ACI Manual of Concrete Inspection*, American Concrete Institute, Detroit, 4th Edition, 1957, 240 pp.

2. Troxell, George E., and Davis, Harmer E., *Composition and Properties of Concrete*, McGraw Hill Book Co., New York, 1956, 434 pp.

3. Parkinson, G. A., Finch, S. P., and Hoff, S. E., "Preliminary Report on Relation Between Strength of Portland Cement Mortar and Its Temperature at Time of Test," *Bulletin* No. 26, Engineering Research Series, University of Texas, 1928.

Discussion of this paper should reach ACI headquarters in triplicate by Feb. 1, 1958, for publication in the June 1958 JOURNAL.

A Critical Look at Slab Design Methods*

By K. E. McKEE† and E. I. FIESENHEISER‡

SYNOPSIS

Curves are presented showing maximum moments in uniformly loaded two-way slabs as calculated under two different basic assumptions. These are: (1) the slabs are isotropic and homogeneous, and (2) the slabs are anisotropic and nonhomogeneous when designed by ACI Methods 1 and 2.§ A glance at the figures shows the different edge conditions, over the full range of variation of side length ratios. Consideration is limited to rectangular slabs supported on all four sides.

INTRODUCTION

Considerable attention was given to a method of curve plotting which would effectively point out the variations in results obtained by different methods of calculation of maximum moments in two-way slabs. It was decided to use a basic procedure prescribed by L. H. Donnell.[18] This particular application of the basic procedure consists in the plotting of dimensionless moments versus the ratio of slab panel side lengths. This ratio a/b varies from 0 to 1 on the left half of each figure. On the right half the ratio b/a varies from 1 to 0. The ratio on the right is therefore the reciprocal of that on the left. Considering only the ratio a/b, its complete range over the entire chart is therefore from 0 to ∞.

There is also a considerable advantage in the use of dimensionless moments. Where the dimension a is a span length, it is customary to calculate moment as $M = Cwa^2$, where C is a moment coefficient, and w is the applied load per unit of area. Solving for the moment coefficient, $C = M/wa^2$. Therefore what is actually plotted here is the moment coefficient. The moment coefficient M/wa^2 is used consistently in all the charts rather than M/wb^2.

In these figures only *maximum* calculated moments at *any* point in the slab are used as it is this maximum moment which controls the required design thickness of the slab. In some cases this maximum moment will occur at the center of the slab panel; in other cases it will occur at the edge support.

HOMOGENEOUS, ISOTROPIC SLABS

Fig. 1-4 present results from the assumption that the slabs are isotropic and homogeneous. This assumption, while nearly correct for plates of steel

*Received by the Institute Nov. 19, 1956. Title No. 54-21 is a part of copyrighted JOURNAL OF THE AMERICAN CONCRETE INSTITUTE, V. 29, No. 5, Nov. 1957. *Proceedings* V. 54. Separate prints are available at 50 cents each. **Discussion** (copies in **triplicate**) should reach the Institute not later than Feb. 1, 1958. Address P. O. Box 4754, Redford Station, Detroit 19, Mich.

†Member American Concrete Institute, Research Engineer, Structural Analysis Section, Armour Research Foundation, Illinois Institute of Technology, Chicago, Ill.

‡Member American Concrete Institute, Professor and Director of Civil Engineering, Illinois Institute of Technology, Chicago, Ill.

§*Building Code Requirements for Reinforced Concrete (ACI 318-56)*, Section 709.

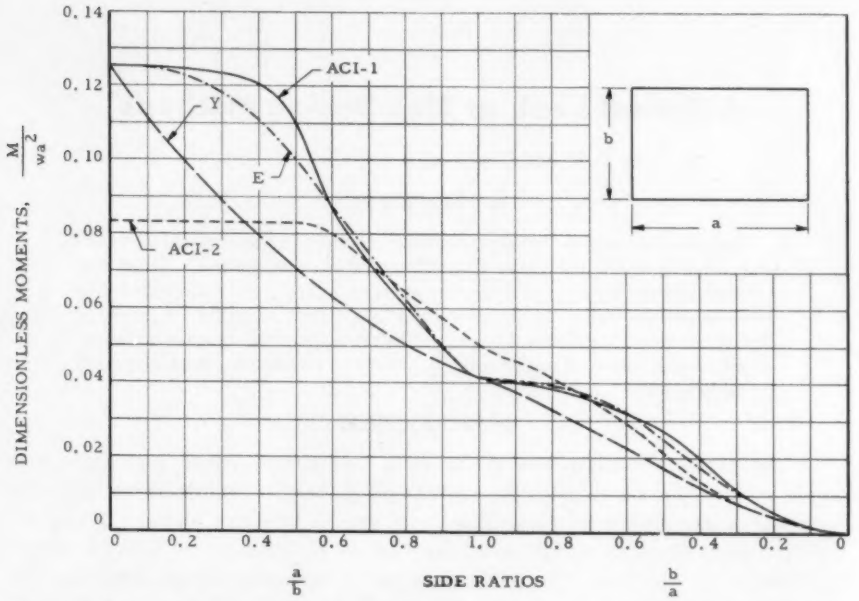


Fig. 1—Maximum moments with four slab edges pinned (isotropic, homogeneous slabs)

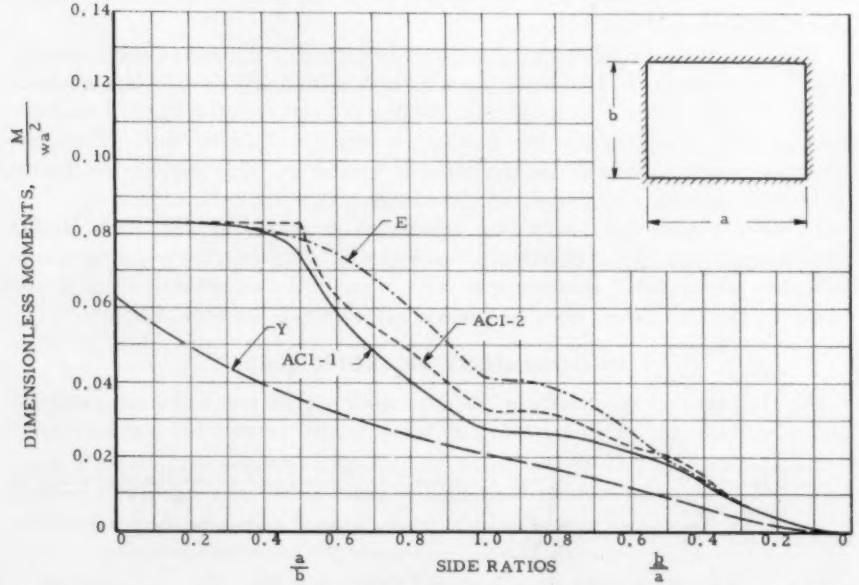


Fig. 2—Maximum moments with four slab edges fixed (isotropic, homogeneous slabs)

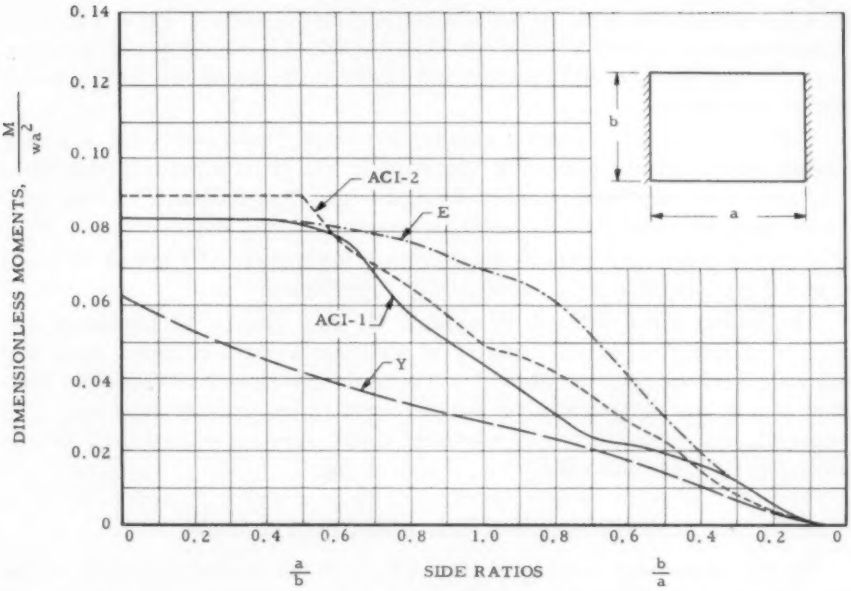


Fig. 3—Maximum moments with edges fixed in the *b* direction (isotropic, homogeneous slabs)

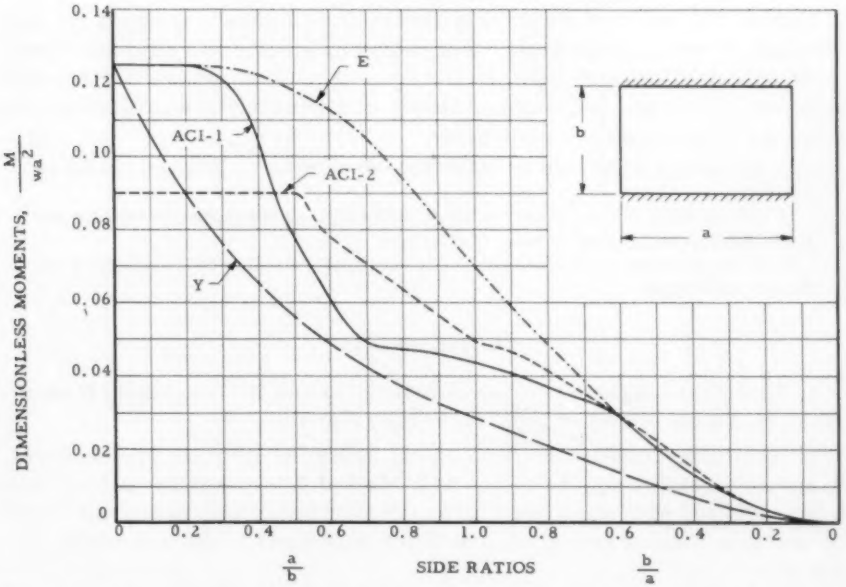


Fig. 4—Maximum moments with edges fixed in the *a* direction (isotropic, homogeneous slabs)

or other metals, has often been made for reinforced concrete. Each of the four graphs applies to different edge conditions as noted in the titles and as shown on each diagram. In each case the results shown are based upon four possible design procedures.

Curves labeled *E* represent maximum moment coefficients for a purely elastic method of analysis using approximate analytical functions (representing numerical solutions) supplied by Westergaard and Slater.[30] These solutions apply theoretically only to homogeneous, isotropic slabs.

Curves representing moment coefficients of the current ACI 318-56 Methods 1 and 2 are labeled as *ACI-1* and *ACI-2* in the figures.

The fourth curve, labeled *Y*, appears on each graph. It represents the results of the "yield-line" method of analysis, a method based upon the ultimate load capacity of the slab. The yield-line theory involves the location of a failure pattern when a slab is loaded to its ultimate capacity. The theory is not restricted to the relatively simple case considered here, i.e., to isotropic, homogeneous slabs.

NONHOMOGENEOUS, ANISOTROPIC SLABS

For the same edge conditions, Fig. 5-8 apply to nonhomogeneous, anisotropic slabs. In these figures *ACI-1* and *ACI-2* curves are the same as in Fig. 1-4 for similar edge conditions, since the ACI Code does not limit the application of these methods to particular types of slabs.

Curves *Y-1* and *Y-2* cover yield-line analyses for slabs designed by ACI Methods 1 and 2, respectively. For these applications the yield-line theory must take into account both anisotropy and nonhomogeneity of the slabs designed. To apply the yield-line theory in a relatively general fashion, the following assumptions are introduced:

1. The corners of the slabs are sufficiently well reinforced so that local failures are avoided.
2. No reduction of steel is used in the column strips, an assumption which increases the ultimate load carrying capacity of the slab.
3. At pinned edges no resisting moment is developed, regardless of the amount of top steel at these edges.

CONCLUSIONS

1. Since final designs of two-way slabs seldom result in homogeneity throughout, Fig. 5-8 are of greater significance than Fig. 1-4.

2. Regarding yield-line calculations as indicating ultimate load moment, it appears wise to limit the use of ACI Method 2 to a/b ratios greater than 0.45 for pinned edge slabs (see Fig. 5). It would also seem desirable to limit its use to a/b ratios greater than 0.25 for slabs fixed in the a direction (see Fig. 8).

3. For panels other than the long, narrow type, the figures demonstrate that ACI Method 1 is more economical than ACI Method 2.

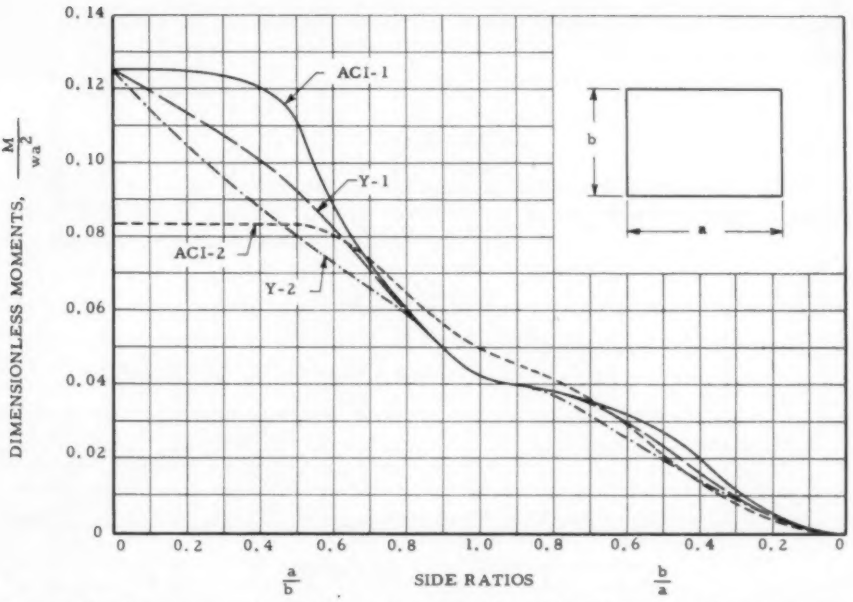


Fig. 5—Maximum moments with four slab edges pinned (anisotropic, nonhomogeneous slabs)

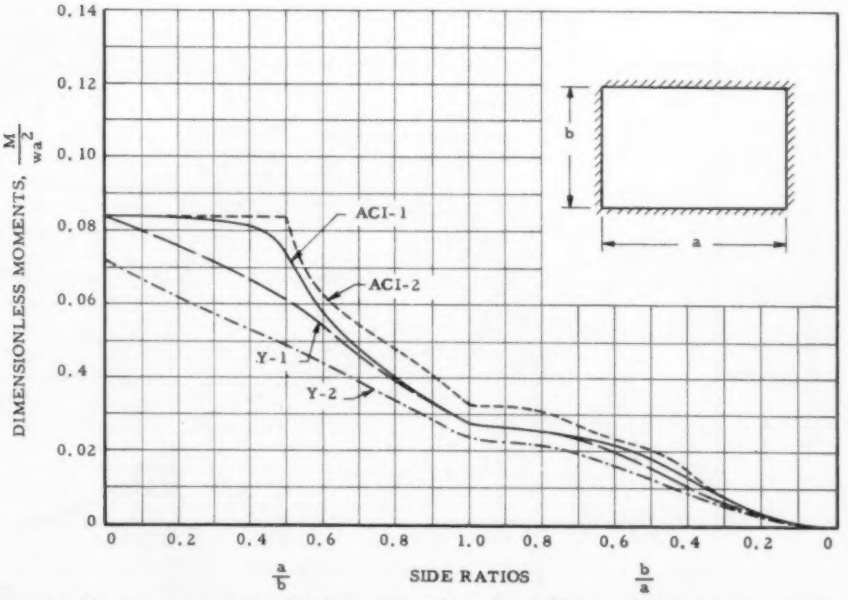


Fig. 6—Maximum moments with four slab edges fixed (anisotropic, nonhomogeneous slabs)

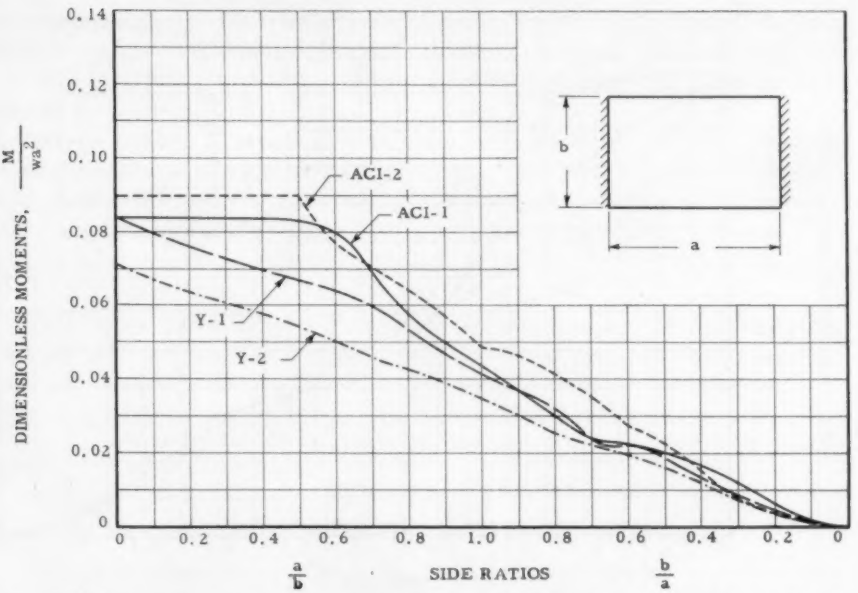


Fig. 7—Maximum moments with edges fixed in the *b* direction (anisotropic, nonhomogeneous slabs)

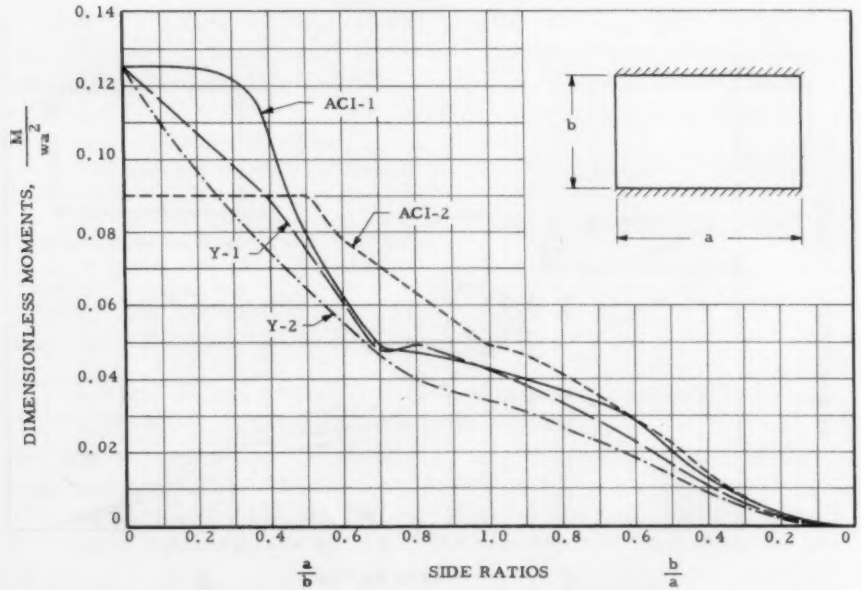


Fig. 8—Maximum moments with edges fixed in the *a* direction (anisotropic, nonhomogeneous slabs)

4. Because of its general usefulness for nonrectangular slabs and its adaptability to nonhomogeneous and anisotropic slabs, it is proposed that the yield-line theory be permitted as an alternate method of slab design.

ACKNOWLEDGMENT

This paper is based on an unpublished thesis submitted in partial fulfillment of the requirements for the degree of master of science in civil engineering in the graduate school of Illinois Institute of Technology by K. E. McKee.

REFERENCES

1. ACI Committee 318, "Building Code Requirements for Reinforced Concrete (ACI 318-56)," ACI JOURNAL, May 1956, *Proc.* V. 52, pp. 913-986.

2. ACI-ASCE Committee 327, "Ultimate Strength Design," ACI JOURNAL, Jan. 1956, *Proc.* V. 52, pp. 505-524. (Also published as Paper No. 809, *Proceedings*, ASCE, V. 81.)

3. Whitney, C. S., Anderson, B. G., and Cohen, E., "Design of Blast Resistant Construction for Atomic Explosions," ACI JOURNAL, Mar. 1955, *Proc.* V. 51, pp. 589-684.

4. "Investigation of Sympathetic Detonation and Evaluation of Structures for Ammunition Manufacture. Final Report—Part II," Armour Research Foundation, Chicago, Nov. 1955.

5. Woods, R. H., "A Preliminary Study of Composite Action in Framed Buildings," *Publications*, International Association for Bridge and Structural Engineering, V. 15, 1955.

6. Hognestad, Eivind, "Yield-Line Theory for the Ultimate Flexural Strength of Reinforced Concrete Slabs," ACI JOURNAL, Mar. 1953, *Proc.* V. 49, pp. 637-664.

7. Westergaard, H. M., *Theory of Elasticity and Plasticity*, John Wiley & Sons, New York, 1952.

8. Corning, Leo H., et al., Symposium on Ultimate Load Design, ACI JOURNAL, June 1952, *Proc.* V. 48, pp. 797-900.

9. Craemer, H., "Slabs Spanning in Two Directions Analyzed by Consideration of Pattern of Fractures," *Concrete and Constructional Engineering* (London), V. 45, No. 8, Aug. 1950, pp. 279-282.

10. Large, G. E., *Basic Reinforced Concrete Design*, Ronald Press, New York, 1950.

11. Johansen, K. W., *Pladeformler*, 2 Udgave, Polyteknish Forening, Copenhagen, 1949, 172 pp.

12. Johansen, K. W., *Pladeformler; Fomelsamling 2*, Udgave, Polyteknish Forening, Copenhagen, 1949, 14 pp.

13. Johansen, W. K., "The Ultimate Strength of Reinforced Concrete Slabs," *Final Report*, Third Congress, International Association for Bridge and Structural Engineering, Liege, Sept. 1948.

14. Siess, C. P., and Newmark, N. M., "Rational Analysis and Design of Two-Way Concrete Slabs," ACI JOURNAL, Dec. 1948, *Proc.* V. 45, pp. 273-316.

15. Bertin, R. L., DiStasio, Joseph, and Van Buren, M. P., "Slabs Supported on Four Sides," ACI JOURNAL, June 1945, *Proc.* V. 41, pp. 537-556.

16. Rogers, Paul, "Two-Way Reinforced Concrete Slabs," ACI JOURNAL, Sept. 1944, *Proc.* V. 41, pp. 21-36.

17. McHenry, Douglas, "Lattice Analogy in Concrete Design," ACI JOURNAL, Oct. 1948, *Proc.* V. 45, Oct. 1948, pp. 129-140.

18. Donnell, L. H., "A Chart for Plotting Relations Between Variables over Their Entire Real Range," *Quarterly for Applied Mechanics*, V. 1, Oct. 1, 1943, p. 276.

19. Johansen, K. W., *Brudlinieteorier*, Jul. Gjellerups Forlag, Copenhagen, Aug. 1943, 189 pp.

20. DiStasio, Joseph, "Flat Plate Rigid Frame Design for Low Cost Housing Projects in Newark and Atlantic City, N. J.," ACI JOURNAL, Feb. 1941, *Proc.* V. 37, pp. 309-324.

21. Timoshenko, S., *Theory of Plates and Shells*, McGraw-Hill Book Co., Inc., New York, 1940.

22. Evans, T., "Moment Deflection Values for a Clamped Rectangular Plate," *Journal of Applied Mechanics*, Mar. 1939, pp. A7-A10.

23. Newmark, N. M., "A Distribution Procedure for the Analysis of Slabs Continuous over Flexible Beams," *Bulletin* No. 304, University of Illinois Engineering Experiment Station, 1938.

24. DiStasio, Joseph, and VanBuren, M. P., "Slabs Supported on Four Sides," ACI JOURNAL, Jan.-Feb. 1936, *Proc.* V. 32, pp. 350-364.

25. Uhler, E. H., "Design of Two-Way Slabs on Beams," ACI JOURNAL, June 1934, *Proc.* V. 30, pp. 504-509.

26. "Slabs in Reinforced Concrete Structures," *Preliminary Publication*, International Association for Bridge and Structural Engineering, Paris, 1932, pp. 191-303.

27. Wise, Joseph, "The Calculation of Flat Plates by Elastic Web Method," *Proceedings*, ACI, V. 24, 1928, pp. 408-423.

28. Westergaard, H. M., "Formulas for the Design of Rectangular Floor Slabs and the Supporting Girders," *Proceedings*, ACI, V. 22, 1926, pp. 26-44.

29. Ingerslev, Aa., "The Strength of Rectangular Slabs," *Journal*, Institution of Structural Engineers, London, V. 1, No. 1.

30. Westergaard, H. M., and Slater, W. A., "Moments and Stresses in Slabs," *Proceedings*, ACI, V. 17, 1921, pp. 415-538.

Discussion of this paper should reach ACI headquarters in triplicate by Feb. 1, 1958, for publication in the June 1958 JOURNAL.

Bearing Capacity of Concrete*

By WILLIAM SHELSON†

SYNOPSIS

Test data obtained in several investigations of the relation between ultimate bearing capacity and the ratio of footing area to loaded area of concrete and rock foundations are summarized. The results show that for the higher ratios (over 10:1), the ACI Code requirements are too conservative. An alternative design formula is proposed.

INTRODUCTION

Too few tests have been carried out on the bearing capacity of concrete and rock to establish any precise empirical law of failure. Nevertheless, the results of these tests have served as a rough guide which has enabled the structural engineer to provide safe footings. However, the trend of recent tests indicates that the margin of safety in footings proportioned according to existing codes[1] may sometimes be appreciably greater than the margin of safety employed in other structural elements.

LOAD TESTS OF BEARING CAPACITY

A test program was carried out to determine the maximum bearing pressure that can be sustained by concrete footings loaded through steel base plates. The investigation made use of small models prepared and tested under controlled laboratory conditions. The effect of rigid versus flexible base plates was also studied. In applying the results of this investigation to the design of actual field structures, an appropriate factor of safety must be included.

Test procedure

The test program consisted of loading 8-in. concrete cubes to failure through mild steel base plates, ¼ in. thick and 1, 1.41, 2, 2.83, and 3 in. square, respectively.

The blocks were made of a high-early-strength mortar with a 1:2.5 cement-sand ratio and a water-cement ratio of 0.50 by weight. The aggregate was screened through a No. 14 sieve (maximum opening 1.168 mm). The choice of a fine aggregate may be debatable, but it was thought that in scaling down the model, the size of aggregate should also be reduced to obtain a closer correspondence of the model with actual construction. For each of the series of tests, the concrete specimens were made the same day, but prepared in batches, each batch consisting of three blocks, three compression test cylinders, and three tension test briquets. The cylinders were 6 x 12 in.; the briquets were of 1 sq in. cross section. All the test pieces were cured in a humidity room at 70 ± 5 F for the 7 days which elapsed between manufacture and test.

*Received by the Institute Sept. 4, 1956. Title No. 54-22 is a part of copyrighted JOURNAL OF THE AMERICAN CONCRETE INSTITUTE, V. 29, No. 5, Nov. 1957, *Proceedings* V. 54. Separate prints are available at 50 cents each. **Discussion** (copies in **triplicate**) should reach the Institute not later than Feb. 1, 1958. Address P. O. Box 4754, Redford Station, Detroit 19, Mich.

†Research Division, The Hydro-Electric Power Commmission of Ontario, Toronto, Ont., Canada.

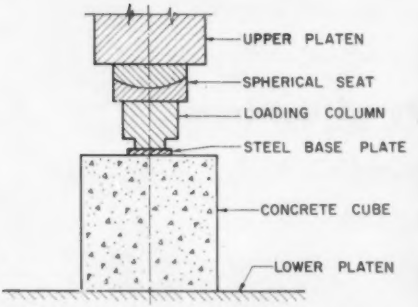


Fig. 1—Loading arrangement

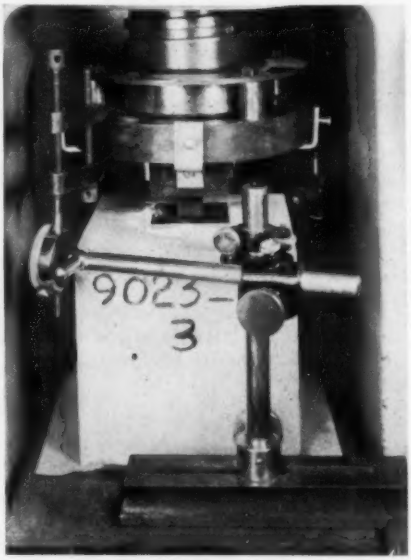


Fig. 2—Loading arrangement (with 1 in. square column)

Simultaneously with the model tests, the supplementary cylinders and briquets were tested by standard procedures to obtain the modulus of elasticity in compression, and the compressive and tensile strengths of the concrete. Thus, accurate data on the properties of the concrete used in the models were obtained (Table 1).

Blocks were loaded in an Amsler hydraulic compression testing machine. Each test consisted of stressing three identical models. It was thus possible to obtain some indication of the scatter of the data, and assess the reliability of the result more easily than would have been permitted by individual tests.

The load was applied to the base plates as shown in Fig. 1 and 2. In some cases, the load was applied to the plate through a loading column which terminated in a bearing surface 1 in. square on the base plate. In the remainder of the tests, the load was applied over the entire surface area of the base plate. The base plate itself was bedded on top of the block in plaster of Paris, and positioned at the center with its edges parallel to those of the block.

The entire model, when placed in the testing machine, rested on a large bearing plate attached to the lower platen; the plate was required to provide adequate bearing area. The loading column was attached to the upper platen through a spherical seat and the lower end

TABLE 1—PROPERTIES OF CONCRETE USED IN BEARING TESTS*

Test No.	Compressive strength, psi	Tensile strength, psi	Modulus of elasticity, psi × 10^6	Test No.	Compressive strength, psi	Tensile strength, psi	Modulus of elasticity, psi × 10^6
1	6720	550	3.96	13	6870	650	—
2	6730	640	3.92	14	6280	645	—
3	6620	610	3.77	15	6280	650	—
4	6530	595	—	16	5850	405	—
5	6170	625	—	17	5870	410	—
6	6240	665	—	18	5620	500	—
7	6300	650	—	19	6480	595	4.19
8	6110	660	—	20	6670	580	3.73
9	6570	690	—	21	6550	605	3.73
10	6540	575	5.72				
11	6580	640	3.81				
12	6540	620	5.62				

*Values are for properties of concrete 7 days after manufacture. Standard 1 sq in. briquets were loaded in tension, 6 x 12-in. cylinders in compression. Modulus of elasticity in compression is noted where measured.

TABLE 2—LOADING TEST RESULTS

Test No.	Area of plate, sq in.	Area of loading, sq in.	Load at failure, lb	Total deflection, in.	Test No.	Area of plate, sq in.	Area of loading, sq in.	Load at failure, lb	Total deflection, in.
1	1	1	32,600	0.0364	13	4	4	85,400	0.0636
2	1	1	34,600	0.0896	14	4	4	79,200	0.0541
3	1	1	32,700	0.1012	15	4	4	74,000	0.0531
4	2	1	59,000	0.0686	16	8	8	82,500	0.0360
5	2	1	51,400	0.0646	17	8	8	94,400	0.0395
6	2	1	62,700	0.0653	18	8	8	79,000	0.0211
7	2	2	65,400	0.0711*	19	9	1	61,600	0.0624
8	2	2	57,600	0.0755	20	9	1	64,200	0.0644
9	2	2	62,000	0.0701	21	9	1	61,400	0.0598
10	4	1	59,200	0.0641					
11	4	1	59,600	0.0685					
12	4	1	55,600	0.0655					

*Reading at 48,000-lb load. No further readings were taken.

of the column was applied to the model base plate. The rate of loading was 500 lb per sec or less, with readings of load and deflection noted at load increments of 2000 lb. The deflection was measured between the lower bearing plate and the upper spherical seat. Thus, the measurements of deflections are not directly indicative of the penetration of the loading column into the model, but include the deformation of the block and loading column as well. However, the contraction of the steel column would be relatively insignificant.

Test results

Table 2 lists data obtained from the model tests. In addition, photographs of typical failures are included as Fig. 3-9. Unfortunately, these photographs cannot adequately depict the three-dimensional form of the fracture.

With the smaller base plates, the failure of the concrete blocks appears to occur in two stages. First, a separate wedge-shaped, solid segment of the block forms directly beneath the base plate. Secondly, this wedge is forced down through the block and splits it. The angle of the wedge is about 60 to 70 deg. Surprisingly, the wedge is not symmetrical, but is either fan-shaped along a diagonal of the plate or is triquetrous, the latter form occurring with the larger base plate. It is not known when the wedge forms, the criterion af failure being the splitting of the block.

With the larger base plates, the formation of a distinctly separate wedge does not occur, although there is the appearance of some internal wedge.

There does not appear to be any considerable stress concentration along the edges and at the corners of the base plates insofar as ultimate failure of the concrete is concerned. This is borne out by the results for failure of the concrete under base plates of 2, 4, and 9 sq in. loaded over 1 sq in. The bearing capacity of the concrete does not seem to be improved by the greater edge flexibility of, say, the 4 sq in. plate over the 2 sq in. plate.

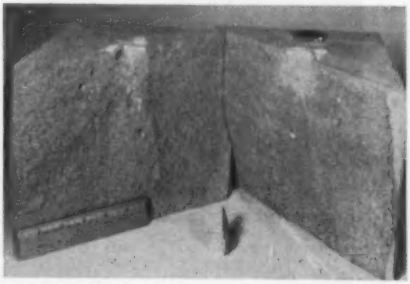


Fig. 3—Model after failure: base plate 1 sq in., loaded area 1 sq in.

Fig. 4—Model after failure: base plate 2 sq in., loaded area 1 sq in.

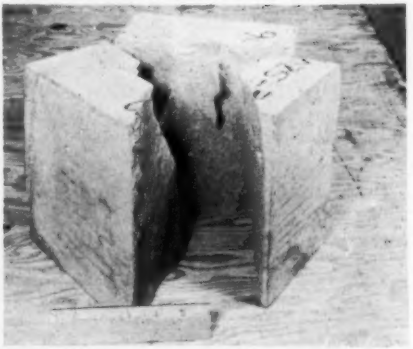


Fig. 7—Model after failure: base plate 4 sq in., loaded area 4 sq in.

Fig. 5—Model after failure: base plate 2 sq in., loaded area 2 sq in.

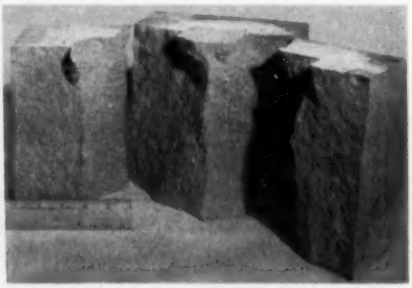


Fig. 8—Model after failure: base plate 8 sq in., loaded area 8 sq in.

Fig. 6—Model after failure: base plate 4 sq in., loaded area 1 sq in.

Fig. 9—Model after failure: base plate 9 sq in., loaded area 1 sq in.

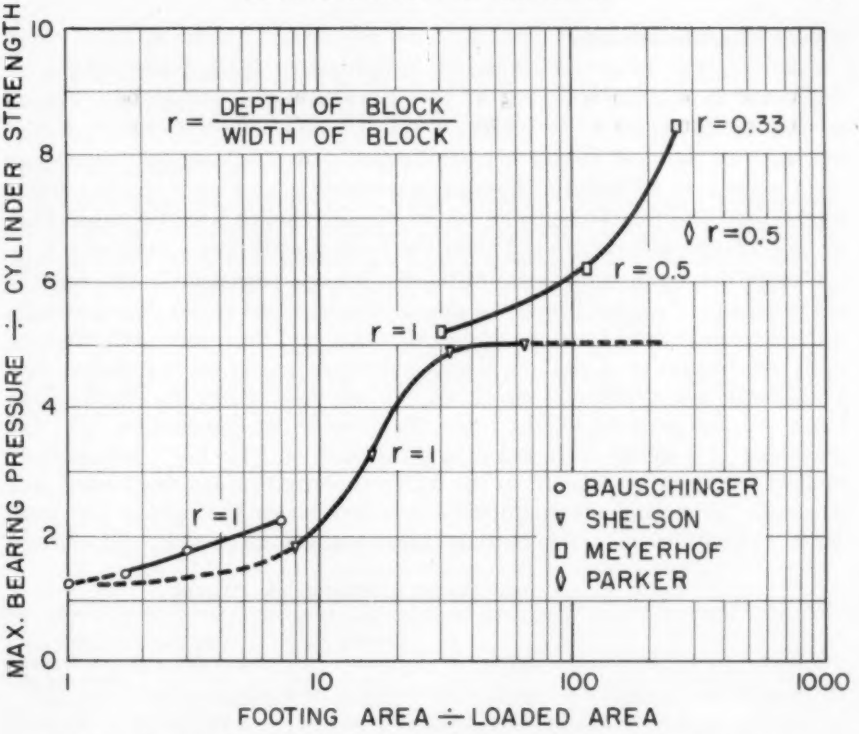


Fig. 10—Test results on the bearing capacity of stone and concrete footings

Considering only the tests with the 2 sq in. base plates, the results are virtually identical although it might be expected that loading over 1 sq in. would produce less stress at the edges and thus more uniform loading on the concrete than over-all loading on the plate. It seems likely that the concrete flows sufficiently under localized high stresses to greatly reduce such stresses, and approximately uniform loading may be realized.

ANALYSIS OF BEARING TEST RESULTS

Fig. 10 has been prepared from results obtained to date by different investigators[2,3,4,5] from bearing tests on concrete and on sandstone. The graph shows the relationship between the ratio of loaded area:footing area and the bearing pressure at failure. The test points obtained in the various investigations have been made comparable by using as the ordinate, the ratio of the bearing pressure to the cylinder compressive strength of the concrete or rock. In those instances where only the cube compressive strength was given, the cylinder compressive stress has been taken as 0.8 of the cube strength. The data upon which the curves are based are given in Tables 2, 3, and 4. Values taken from Table 2 are those for which the area of plate and area of loading were identical.

Effect of depth:width ratio

Curves in Fig. 10 do not suggest any single clearly defined trend of the influence of the footing area:loaded area ratio on bearing capacity; indeed, several trends appear to be present. The different curves do not, however, represent similar test results since the ratios of depth:width of footing are not the same in all cases. The models used by Bauschinger and the writer were cubes, whereas the concrete blocks of Meyerhof had depth:width ratios of 1:1, 1:2, and 1:3, respectively, and the Parker model had a ratio of 1:2.

Clearly the depth:width ratio of the block has a considerable effect on the bearing load at failure. It must be remembered that the blocks were generally bedded on heavy steel platens during the tests, and the results are not necessarily representative of shallow blocks bedded on soil or other material with a relatively low modulus of elasticity. In the tests where the depth of the block was relatively small, the mode of failure is not comparable with that prevailing in a model with a depth:width ratio of 1:1. For comparatively shallow blocks on steel platens, the region directly beneath the loaded area is subject to a generally uniform compressive stress throughout the total depth. Conditions favorable to wedge formation are not present, and splitting

TABLE 3—LOADING TESTS REPORTED BY OTHERS

Area of punch, sq in.	Area of footing,† sq in.	Depth of footing, in.	Bearing stress at failure, psi	Concrete strength	
				Compressive,‡ psi	Modulus of rupture, psi
Meyerhof—Reference 5					
1.23*	36	6	16,500	3970	645
1.23	36	6	15,200	2940	545
1.23	36	6	13,400	3630	520
1.23	36	6	13,000	3150	585
1.23	36	6	12,800	2590	525
1.23	144	6	13,500	2940	545
1.23	144	6	19,000	3630	520
1.23	324	6	18,600	2940	545
1.23	324	6	25,600	3630	520
Parker—Reference 2					
2.00†	576	12	25,600	4060	—

*Circular (1.25 in. diameter)
†Square
‡Cube test piece (6 x 6 in.)

TABLE 4—LOADING TESTS* REPORTED BY BAUSCHINGER[6]

Footing area / Bearing area	Bearing stress at failure, psi	Compressive strength	
		Cube, psi	Cylinder,† psi
1.7	10,600	9500	7600
3.0	13,100	9500	7600
7.0	17,000	9500	7600

*Tests on sandstone
†Estimated

of the block or penetration of the wedge is thus retarded. The test results indicate that for a given ratio of footing area:loaded area, the maximum bearing pressure increases as the depth:width ratio decreases. This conclusion applies only to concrete block bedded on massive steel bases.

Tests with sandstone cubes

It has become widely known as a result of Bauschinger's tests on sandstone, the details of which were published in 1876, that the maximum bearing pressure that may be applied to rock and concrete footings increases as the ratio of footing area to loaded area increases. Bauschinger's tests were made on sandstone cubes, and extended over a narrow range of ratios of footing area: loaded area (1:1 to 7:1 approximately).

Bauschinger's data[4] may be approximately represented by the simple mathematical relation:

$$f = f_c' \sqrt[3]{\frac{A}{A'}}$$

where f = maximum bearing pressure
f_c' = compressive (cube) strength of the sandstone
A = total area of the footing
A' = loaded area on top of the footing

Tests with concrete cubes

The desirability of tests on concrete as well as rock has encouraged recent concrete bearing tests. Results obtained using concrete cubes instead of sandstone do not follow any simple mathematical relation. The relevant available test results for concrete have been plotted separately in Fig. 11, where the dotted lines represent the writer's opinion of the form of the curve outside the range of test results. The following characteristics of the test results may be noted:

1. There is reasonably good agreement between the single test point entered from Meyerhof's results and the adjacent part of the curve plotted from the tests by the writer.
2. For relatively low ratios of footing area:loaded area, the maximum bearing pressure increases considerably as the ratio increases.
3. For high ratios of footing area:loaded area (say above 30:1) and for $r = 1$ and presumably for $r > 1$, the maximum bearing pressure tends toward an asymptotic relation with a limit only slightly greater than its value for a ratio of 30:1. This limit will approach the maximum bearing pressure for a semi-infinite footing.

Comparison with ACI Building Code

As an indication of the adequacy of the bearing stresses permitted by the ACI Building Code, the test curve of Fig. 11 has been plotted together with a comparable curve obtained from the specifications of the Code.[1] In plotting the latter curve, the permissible bearing stresses given by the Code have been multiplied by an assumed factor of safety of four to provide the probable curve of failure implicit in the Code.

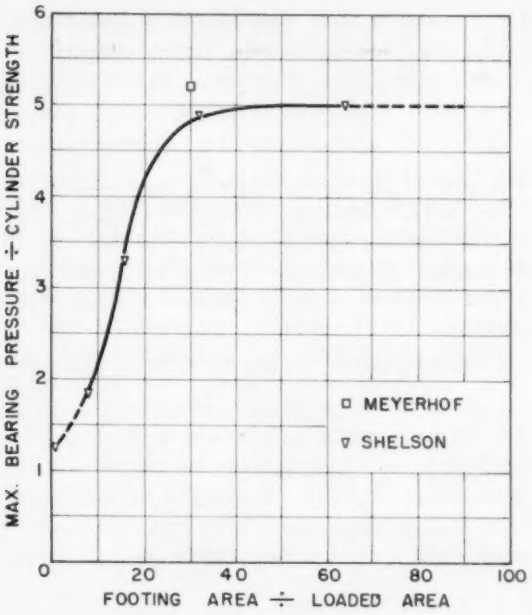


Fig. 11—Bearing capacity of concrete

The curves (Fig. 12) indicate that the present Code provides a more than ample margin of safety at the higher ratios of footing area:loaded area. However, at the lower ratios which are more common in practice, the test results indicate that the desired margin of safety is not fully attained.

There is a need for more experimental work on the failure of concrete footings where the ratios of footing area:loaded area are less than 8:1. Apparently the only extensive data in this region are Bauschinger's. He worked with sandstone blocks and the test results cannot be applied to concrete without serious reservations.

A more realistic and reasonable design formula than existing specifications could be of the simple form:

$$f_c = 0.25 f_c' R^{0.3}$$

where f_c = permissible bearing pressure (psi)
R = ratio of footing area : loaded area
f_c' = ultimate compressive strength of concrete at 28 days

The curve of the equation has been plotted on a comparative basis in Fig. 12 and follows the actual failure curve more closely than the ACI Code requirement. At the lower end, this curve provides a permissible stress in accord with the Code. For the higher ratios of footing area:loaded area, the curve still remains quite conservative but permits an improvement in design in accord with modern test data.

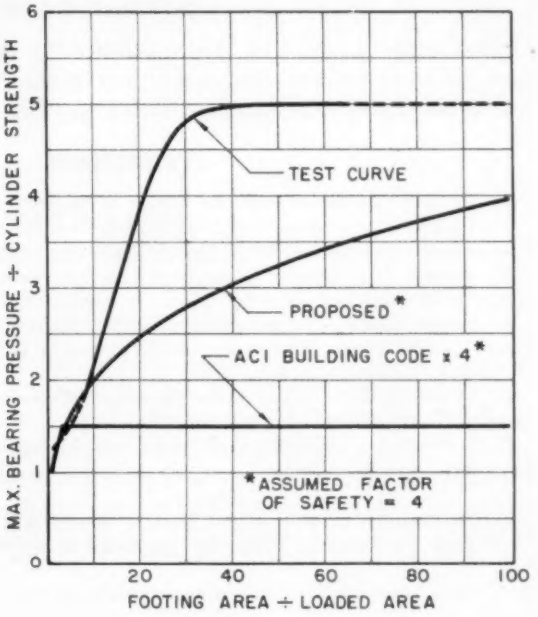


Fig. 12—Comparison of experimental and permissible bearing capacity of concrete

CONCLUSIONS

Recent tests on the bearing capacity of plain concrete under base plates have served to fill an important gap in the experimental data. The most reliable relation found between bearing pressure and ratio of footing area:loading area is that given in Fig. 12. This relation supports the widely held belief that the permissible concrete bearing pressure under base plates may be increased with an increase in the ratio of footing area:loaded area.

However, this relationship, also indicates that the bearing pressure at failure apparently approaches a limiting value for ratios over approximately 30:1. The depth of the footing was found to influence considerably the maximum bearing pressure.

A comparison of the relation found above, and the specifications of the ACI Building Code reveals that for lower ratios of footing area:loaded area, the specifications of the Code may result in a slightly lower factor of safety than anticipated while for ratios higher than 10:1, the specifications are too conservative. The following formula is proposed for the permissible bearing pressure on concrete:

$$f_c = 0.25 f_c' R^{0.3}$$

where R = ratio of footing area : loaded area

ACKNOWLEDGMENT

The author thanks The Hydro-Electric Power Commission of Ontario for permission to publish this paper, and acknowledges the assistance of his associates in the Structural Research Department in the tests described.

REFERENCES

1. *Building Code Requirements for Reinforced Concrete* (*ACI 318-56*), Section 305.
2. Parker, W., "Loading Tests on Limited Areas of Concrete Specimens," *Report* LO 40424, Research Division, Hydro-Electric Power Commission of Ontario, 1947.
3. Shelson, W., "Bearing Capacity of Concrete under Base Plates," *Report* No. 53-94, Research Division, Hydro-Electric Power Commission of Ontario, 1953.
4. Bauschinger, J., "Versuche mit Quadern aus Natursteinen (Tests with Blocks of Natural Stone)," *Mitteilungen*, Mechanisch und Technischen Laboratorium der Kgl. Technischen Hochschule, Munich, V. 6, 1876, p. 13.
5. Meyerhof, G. G., "The Bearing Capacity of Concrete and Rock," *Magazine of Concrete Research* (London), V. 4, 1953, pp. 107-116.
6. Johnson, J. B., Withey, M. O., and Aston, J., *Materials of Construction*, John Wiley & Sons, Inc., New York, 1939.

Discussion of this paper should reach ACI headquarters in triplicate by Feb. 1, 1958, for publication in the June 1958 JOURNAL.

Title No. 54-23

Temperature Stresses in Continuous Frames*

By SAM HASSID†

SYNOPSIS

This paper explains briefly a distribution method which has been found useful in analyzing frames subjected to temperature changes.

DESCRIPTION OF THE METHOD

Let all joints in a structure be held against rotation and horizontal displacement while the beams develop axial forces due to temperature changes. One joint is then allowed to displace horizontally, but not to rotate, with accompanying distribution of the unbalanced axial force to the members of the joint. The resulting axial forces and shears are carried over to the adjacent joints; then another joint is allowed to displace but not to rotate while the others are held against rotation and horizontal displacement; the process is repeated until all joints are "eased down" into equilibrium.

During the distribution of the unbalanced axial forces the joints were held against rotation. From the final shears obtained the fixed-end moments at the top and bottom of each column can be computed. Assume that all joints are held against horizontal displacement and distribute all moments by the well-known moment distribution method.

From the final moments find the unbalanced shears, at the top and bottom of each column, and distribute them assuming that all joints are held against rotation (as in the first distribution of axial forces). After distributing all unbalanced shears, perform a new moment distribution assuming that all joints are held against horizontal displacement. The process of distributing unbalanced shears and moments respectively will be repeated until they are small enough to be neglected. Superimpose the values yielded in each cycle, axial forces, moments and shears, to obtain the final values, when the structure is completely unrestrained externally.

DISTRIBUTION OF THE UNBALANCED AXIAL FORCE

Notation

L = length of beam
h = height of column
A = cross sectional area of beam
I = moment of inertia of column
Δ = horizontal displacement of joint
P = axial force in beam
V = shear force in column
E = modulus of elasticity
t = temperature change
λ = coefficient of thermal expansion

*Received by the Institute Dec. 26, 1956. Title No. 54-23 is a part of copyrighted JOURNAL OF THE AMERICAN CONCRETE INSTITUTE, V. 29, No. 5, Nov. 1957, *Proceedings* V. 54. Separate prints are available at 50 cents each. **Discussion** (copies in **triplicate**) should reach the Institute not later than Feb. 1, 1958. Address P. O. Box 4754, Redford Station, Detroit 19, Mich.

†Member American Concrete Institute, Chief Structural Engineer, Ammann and Whitney, Paris, France.

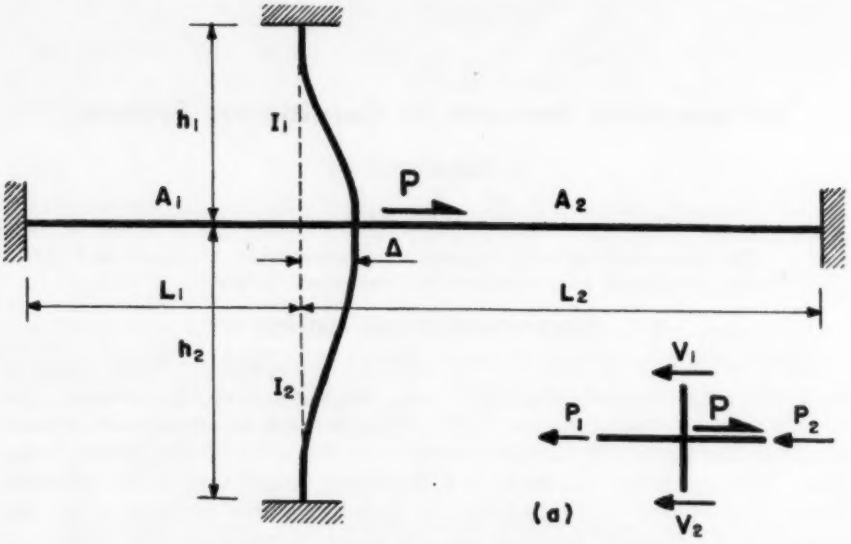


Fig. 1—Distribution of unbalanced axial force

Distribution factors

The unbalanced axial force P shown in Fig. 1 will be distributed while the joint is held against rotation. All other joints in the structure are held against rotation and horizontal displacement. Beams and columns are assumed to be of constant cross section.

Let Δ be the displacement of the joint and P_1, P_2, V_1, V_2, the axial forces and shear forces acting on the joint [see Fig. 1(a)]. From the equation of equilibrium one has:

$$P = P_1 + P_2 + V_1 + V_2 \quad \ldots\ldots(1)$$

According to Hooke's law:

$$\Delta = \frac{P_1 L_1}{EA_1} = \frac{P_2 L_2}{EA_2} \quad \ldots\ldots(2)$$

Since the joint is held against rotation, one may write:

$$\Delta = \frac{V_1 h_1^3}{12EI_1} = \frac{V_2 h_2^3}{12EI_2} \quad \ldots\ldots(3)$$

Equating the values from Eq. (2) and (3), one obtains the following equations:

$$\Delta = \frac{P_1}{\frac{EA_1}{L_1}} = \frac{P_2}{\frac{EA_2}{L_2}} = \frac{V_1}{\frac{12EI_1}{h_1^3}} = \frac{V_2}{\frac{12EI_2}{h_2^3}} \quad \ldots\ldots(4)$$

or,

$$\Delta = \frac{P_1 + P_2 + V_1 + V_2}{\frac{EA_1}{L_1} + \frac{EA_2}{L_2} + \frac{12EI_1}{h_1^3} + \frac{12EI_2}{h_2^3}}$$

Substituting the numerator, from Eq. (1):

$$\Delta = \frac{P}{\frac{EA_1}{L_1} + \frac{EA_2}{L_2} + \frac{12EI_1}{h_1^3} + \frac{12EI_2}{h_2^3}} \qquad (5)$$

From Eq. (4) and (5), solving for P_1, P_2, V_1, V_2 one obtains the axial forces and shears. Hence $P_1 = PK_1$, $P_2 = PK_2$, $V_1 = PK_1'$, $V_2 = PK_2'$, where

$$K_1 = \frac{\frac{A_1}{L_1}}{\frac{A_1}{L_1} + \frac{A_2}{L_2} + \frac{12I_1}{h_1^3} + \frac{12I_2}{h_2^3}}$$

$$K_2 = \frac{\frac{A_2}{L_2}}{\frac{A_1}{L_1} + \frac{A_2}{L_2} + \frac{12I_1}{h_1^3} + \frac{12I_2}{h_2^3}}$$

$$K_1' = \frac{\frac{12I_1}{h_1^3}}{\frac{A_1}{L_1} + \frac{A_2}{L_2} + \frac{12I_1}{h_1^3} + \frac{12I_2}{h_2^3}}$$

$$K_2' = \frac{\frac{12I_2}{h_2^3}}{\frac{A_1}{L_1} + \frac{A_2}{L_2} + \frac{12I_1}{h_1^3} + \frac{12I_2}{h_2^3}}$$

The coefficients K_1, K_2, K_1', K_2' are the distribution factors of the unbalanced axial force at the joint. If the end of a column is hinged, instead of fixed, substitute $3I/h^3$ for $12I/h^3$ in the distribution factors.

Carry-over factor

The unbalanced axial force P develops at the far end of each beam and column respectively, axial forces and shears, which are equal and opposite to axial forces and shears at the joint. Hence the carry-over factor for axial forces and shears is equal to -1. Fig. 2 illustrates carry-over process.

The method of distribution of an unbalanced axial force is summarized on the following page.

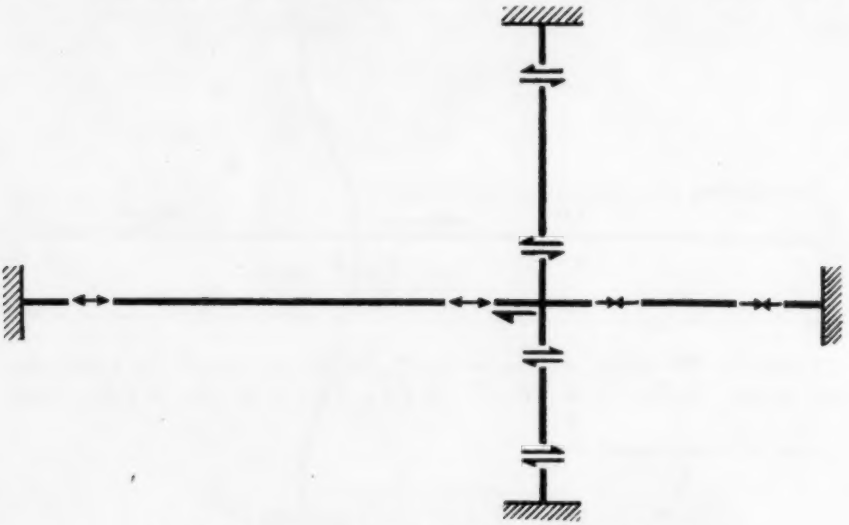


Fig. 2—Carry-over process for unbalanced axial force

1. Assume all joints in the structure held against rotation and displacement and compute the axial forces in the beams for this condition:

$$\frac{PL}{EA} = Lt\,\lambda, \text{ hence } P = EAt\,\lambda$$

2. At each joint distribute the unbalanced axial force among the connecting members by using the distribution factors. The joint is held against rotation.
3. Multiply the axial forces and shears by the carry-over factor and set this product at the other end of the member.
4. Distribute these axial forces and shears just carried-over.
5. Repeat the process until the axial forces and shears to be carried over are small enough to be neglected.
6. Add all axial forces and shears respectively—fixed-end, distributed, carried-over—at each end of each member.

ILLUSTRATION

The illustration given is entirely academic. It is not intended to represent any particular type of structure nor any probable condition of temperature changes in the structure. Distribution factors are shown at each joint (Fig. 3).

Joint 1: 0.3 for the column, 0.7 for the beam
Joint 2: column: 0.2; beam 2-3: 0.4; beam 2-1: 0.4, etc.

Sign convention

Axial forces and shears acting on a joint from left to right are assumed positive [Fig. 4(a)]. Hence for a beam in compression the axial force acting on the right hand joint is positive and the left hand joint is negative; for a beam in tension the signs are reversed. See Fig. 4(b) and 4(c).

The carry-over factor is -1.

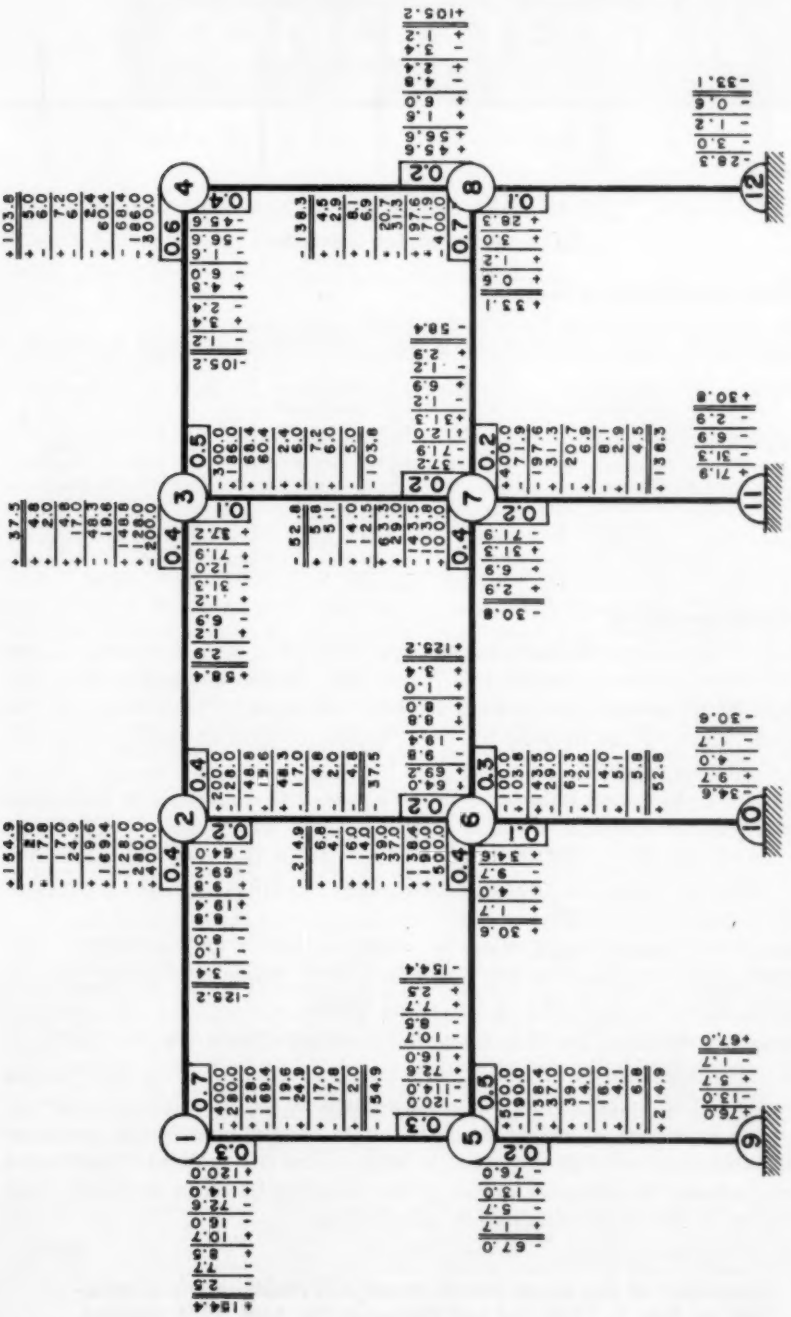


Fig. 3—Numerical example

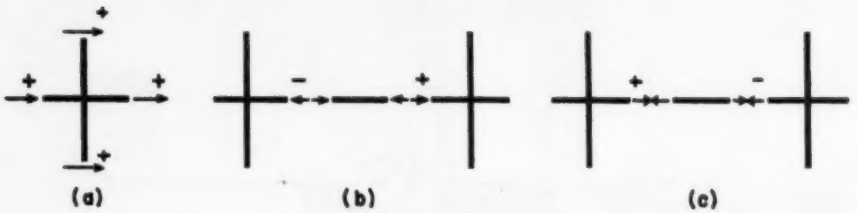


Fig. 4—Adopted sign convention

Fixed-end axial forces in beams

The table below summarizes the fixed-end axial forces.

Beam	Tension or compression	Joint	Fixed-end axial force	Joint	Fixed-end axial force
1-2	Compression	1	−400	2	+400
2-3	Tension	2	+200	3	−200
3-4	Compression	3	−300	4	+300
5-6	Tension	5	+500	6	−500
6-7	Compression	6	−100	7	+100
7-8	Tension	7	+400	8	−400

Distribution procedure

Joint 1—Distribute the unbalanced axial force of −400. Column : + 400 × 0.3 = + 120; beam : + 400 × 0.7 = +280. Draw the lines to show that the joint is in equilibrium without external restraint. Carry over the distributed values by multiplying by −1. Hence, column at Joint 5 : − 120, beam at Joint 2: −280.

Joint 2—Unbalanced axial force = + 400 − 280 + 200 = + 320. Distributed values : Column : − 320 × 0.2 = −64; Beam 2-1 : −320 × 0.4 = −128; Beam 2-3 : −320 × 0.4 = −128. Draw the lines and carry over the distributed values by changing their sign. Column : + 64; Beam 2-1: + 128; Beam 2-3 : + 128.

Joint 3—Unbalanced axial force = −200 + 128 − 300 = −372. Distributed values : Column : + 372 × 0.1 = + 37.2; Beam 3-2: + 372 × 0.4 = + 148.8; Beam 3-4 : + 372 × 0.5 = + 186.0.

Carry-over—Column : −37.2; Beam 3-2 : −148.8; Beam 3-4 : − 186.0.

The operations can be followed very easily on Fig. 3. Four distribution cycles yielded unbalanced forces small enough to be practically neglected. If absolute exactness is desired the distribution procedure must be continued until all unbalanced forces are equal to zero. This is a method of successive approximations; the designer can stop the distribution when he thinks that the degree of exactness obtained is satisfactory.

Discussion of this paper should reach ACI headquarters in triplicate by Feb. 1, 1958, for publication in the June 1958 JOURNAL.

CONCRETE BRIEFS

Notes from Field and Office

Lapped Splices in Reinforced Concrete Beams.....421
Expanded Shale or Clay Concrete.....422
Ultimate Flexural Strength of Prestressed Concrete Beams.....423

Lapped Splices in Reinforced Concrete Beams—Discussion

By K. HAJNAL-KÓNYI*

In the authors' closure to discussion of "Lapped Splices in Reinforced Concrete Beams" (ACI JOURNAL, Oct. 1955, *Proc.* V. 52, pp. 201-214), Messrs. Chinn, Ferguson, and Thompson stated (p. 1159, ACI JOURNAL, Dec. Part 2, 1956) that they "know of no reliable method of establishing what stirrups are necessary to prevent premature splitting," and that "a spiral around the splice could certainly prevent premature splitting." They have raised the question "how many and what type of stirrups are required to function as well as a spiral." The answer is that this can only be found out by further experiments and that research is urgently needed.

Splices of 10.43 in. length of #5 bars, i.e., 16.7 times the bar diameter, as tested by the authors, are certainly inadequate even with stirrups. To develop the yield stress of 62,900 psi an average bond stress of 950 psi or 29.7 percent of f_c' would have been necessary. Inadequate length of the splice cannot be compensated for by stirrups. The purpose of the stirrups is not the shortening of the splice but the prevention of splitting the concrete. This is not a question of economy but a question of safety.

In the case of prestressed concrete there can be no argument about the necessity of transverse reinforcement at the ends of a beam where the prestressing force is transferred since the omission of such reinforcement results in failure. In the case of splices the consequences are not so obvious but nevertheless they exist.

Twenty-two years ago, Gilkey and Ernst† made the following statement: "One of the greatest needs in the field of reinforced concrete generally (regardless of the grade of the steel used) is a thorough-going search for improvement in the anchorage of bars."

This statement is even more relevant today than when it was made. The high potential bond strength of deformed bars (which are now generally used in the United States) is wasted unless the splitting of the concrete is prevented at their ends.

The authors have mentioned the junction of a retaining wall to its base where no transverse reinforcement is required. This is an entirely different case from a beam. While it may not be possible to draw a theoretically exact boundary between a rectangular beam and a slab, in practice the distinction is automatic. In beams a high concentration of stresses occurs with deformed bars comparable to the case of a prestressed concrete beam; in slabs the stresses are distributed over a relatively large mass of concrete since the spacing of the bars is many times their diameter. Consequently, the tendency to split concrete is much reduced.

A part of copyrighted JOURNAL OF THE AMERICAN CONCRETE INSTITUTE, V. 29, No. 5, November 1957, *Proceedings* V. 54. Separate prints of the entire Concrete Briefs section are available at 35 cents each. Address P. O. Box 4754, Redford Station, Detroit 19, Mich.

*Member American Concrete Institute, Consulting Engineer, London, England.

†Gilkey, H. J., and Ernst, G. C., "Report of Project Committee on the Use of High Elastic Limit Steel as Reinforcement of Concrete," *Proceedings*, Fourteenth Annual Meeting of the Highway Research Board, Washington, D. C., Dec. 6-7, 1934, Part I, 1935, pp. 255-314.

Expanded Shale or Clay Concrete

By F. A. BLAKEY and R. D. HILL*

The papers by Washa[1] and Kluge[2] provide a most interesting and useful consolidation of the present knowledge of structural lightweight aggregate concrete, and the results of some experiments on Australian expanded clays and shales may be of interest as a comparison.

Expanded shales and clays are not yet produced commercially in Australia, but experimental work on this type of material has been in progress for 5 years. Some expanded material has been produced in a pilot kiln at the Division of Building Research, using clays and shales collected from many different parts of Australia.

The detailed results of these tests have been reported elsewhere[3,4] but the general conclusions are in agreement with those of Washa and Kluge. Compressive strengths exceeding 7000 psi at 28 days were recorded for saturated, surface-dry, 4-in. concrete cubes, in one case at an air-dry density of 86 lb per cu ft, and in another case at an air-dry density of 94 lb per cu ft.

Tests on these cubes revealed a wide scatter in the plot of compressive strength against water-cement ratio, and an alternative method of design was proposed, based on the theory[5] which relates strength to the volume of voids in the cement phase of the concrete. It was assumed that the nonevaporable water in the concrete at the time of test (28 days) was 35 percent by weight of the cement, and voids occupied by the remainder of mixing water were expressed as percent of the volume of the cement paste phase.

Thus if w_c = water content of paste, after allowing for absorption of aggregate; w_n = nonevaporable water content of paste; and c = absolute volume of cement, the percentage voids ratio of the paste is:

$$\frac{w_c - w_n}{w_c + c} \times 100$$

In all mixes the aggregates were used in a saturated, surface-dry condition. Fig. 1 shows the relationship between the percentage voids ratio and the compressive strength

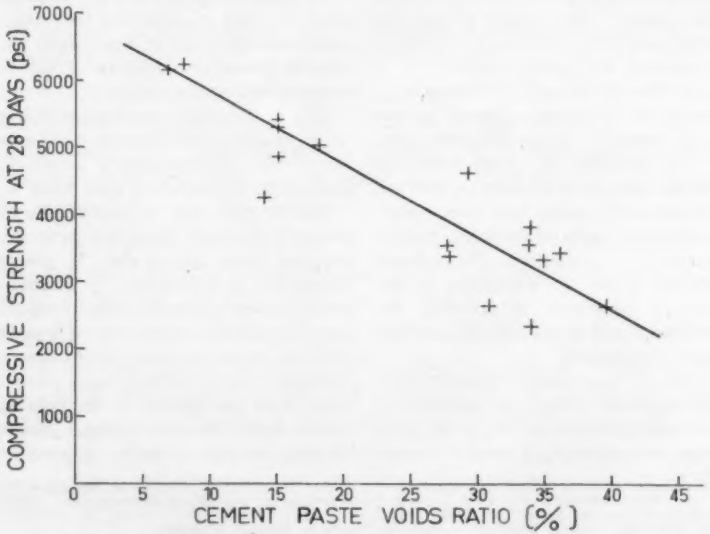


Fig. 1—Relation between compressive strength and voids ratio

*Division of Building Research, Commonwealth Scientific and Industrial Research Organization, Melbourne, Australia.

when w_e is equivalent to a water-cement ratio of 0.35. There is good correlation between strength and voids ratio; correlation coefficient is 0.89.

At this stage, the assumed ratio of nonevaporable water to cement is an empirical parameter for which no complete physical explanation can yet be given. It was derived from measured oven-dry densities of specimens at 28 days, when it was found that the average water-cement ratio of the dried specimens was 0.35. When this value is used to calculate the dry density of the concrete the results show a good correlation (correlation coefficient 0.92) with the measured oven-dry densities, as shown in Fig. 2.

The water bound by the complete hydration of cement is usually considered to be between 0.15 and 0.20 when expressed as a water-cement ratio by weight, and it does not seem possible that water in excess of this amount should contribute to the strength of the concrete. The assumption made, however, implies that water in excess of 35 percent by weight of the cement detracts from the strength; furthermore some of this water is probably retained in the aggregate, and not in the paste.

Nevertheless, as an arbitrary parameter it provides a reliable method of predicting the strength and oven-dry density of lightweight concretes made from a wide variety of clay and shale aggregates. The relation between paste voids ratio and strength is independent of aggregate-cement proportions over the limited test range (6 and 8 bags per cu yd).

The calculation of the paste voids ratio is simple enough to form the basis of a method of mix proportioning, and its relation to strength appears to be linear rather than hyperbolic.

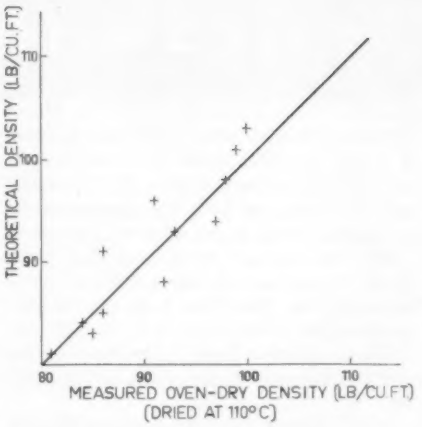


Fig. 2—Relation between theoretical density and measured oven-dry density

REFERENCES

1. Washa, G. W., "Properties of Lightweight Aggregates and Concretes," ACI JOURNAL, Oct. 1956, *Proc.* V. 53, pp. 375-382.

2. Kluge, R. W., "Structural Lightweight-Aggregate Concrete," ACI JOURNAL, Oct. 1956, *Proc.* V. 53, pp. 383-402.

3. Hill, R. D., and Blakey, F. A., "Expanded Clay Aggregates for Concrete," *Constructional Review* (Sydney), V. 26, No. 6, 1953, pp. 22-26.

4. Blakey, F. A., and Hill, R. D., "Further Tests on Materials for Lightweight Structural Concrete," *Constructional Review* (Sydney), V. 28, No. 5, 1955, pp. 19-26.

5. Hummel, A., "Von der Technologie des hochfester Betons," *Zement-Kalk-Gips* (Wiesbaden), V. 7, 1954, pp. 331-337.

Ultimate Flexural Strength of Prestressed and Conventionally Reinforced Concrete Beams—Discussion

By K. HAJNAL-KÓNYI*

The data given by Gene M. Nordby (ACI JOURNAL, Part 2, Dec. 1956, *Proc.* V. 52, p. 1386) are valuable for checking the validity of the equations for ultimate strength in the paper by Jack R. Janney, Eivind Hognestad and Douglas McHenry (ACI JOURNAL, Feb. 1956, *Proc.* V. 52, pp. 601-620). It should be noted that the first two values in Nordby's Table A represent each of the averages of six identical beams.

*Member American Concrete Institute, Consulting Engineer, London, England.

Mr. Nordby has not stated the coefficients on which the curve in his Fig. B is based. I have therefore replotted (Fig. 1) his test results against two curves, both representing Eq. (3) of the original paper. For the sake of simplicity, I have introduced the notation $\alpha = k_2/k_1 k_3$. The upper line corresponds to $\alpha = 0.52$ as assumed by Janney, Hognestad and McHenry; the lower line corresponds to $\alpha = 0.65$ which is the coefficient given in Table 2 of a paper by Eivind Hognestad, N. W. Hanson and Douglas McHenry (ACI JOURNAL, Dec. 1955, *Proc.* V. 52, pp. 455-480) as the value for concrete of $f_c' = 6000$ psi.

The q_u values in Table A are based on the ultimate strength of the wires, i.e., 272,000 psi.

It will be seen from the enclosed diagram that Eq. (3) with $\alpha = 0.65$ gives a safe estimate of the ultimate strength since the two experimental values which are below this curve are so near to it that the difference is negligible. On the other hand the curve with $\alpha = 0.52$ represents a good average. In the range of such high values of q_u as given in Table A (between 0.330 and 0.431) the results are very sensitive to slight variations of the concrete strength and the agreement between the experimental results and the two curves could hardly be better.

Mr. Nordby's results are in good agreement with results obtained in Great Britain and on the Continent and are particularly interesting since the majority of published tests is confined to smaller values of q_u. They confirm that *if the wires are well bonded* Eq. (3), with f_{su} = ultimate strength can be relied upon even if q_u is of the order of 0.4 and that the introduction of values such as $F\epsilon_u$ and ϵ_{su} into the calculation only complicates the issue and does not improve the agreement between theoretical and actual values.

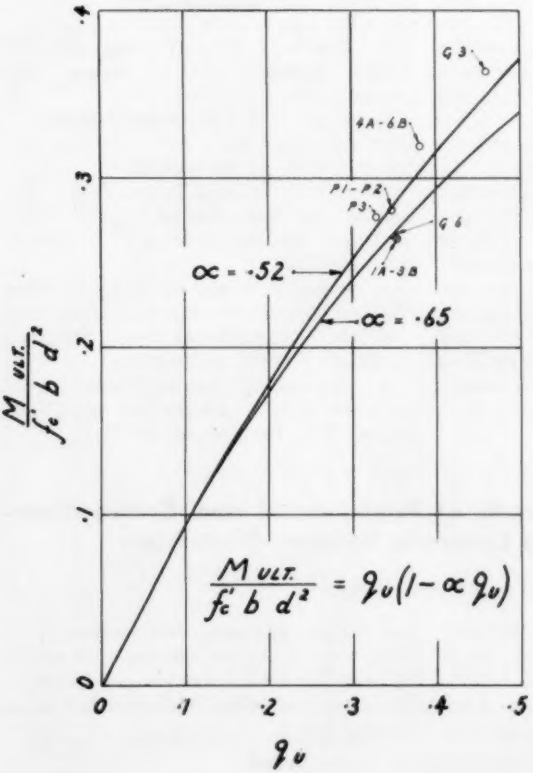


Fig. 1—Comparison of Nordby's results with Eq. (3)

CURRENT REVIEWS

of Significant Contributions in Foreign and Domestic Publications

Bridges

Widening old narrow bridges—Illinois has state-wide program

R. R. BARTELSMEYER, *Roads and Streets*, V. 100, No. 8, Aug. 1957, pp. 44, 45, 49

Describes the widening methods which have been applied to over 100 old bridges, particularly the conventional type of reinforced concrete slab and reinforced concrete deck girder bridges. Describes methods and illustrates cross-section details employed for both cast-in-place, precast, and prestressed widenings.

Design of reinforced and prestressed bridges

R. MORANDI, *Concrete and Constructional Engineering* (London), V. 52, No. 7, July 1957, pp. 237-245

An abstract of the paper "Modern Conceptions in the Planning of Bridges in Reinforced Concrete and in Prestressed Concrete." Describes monumental arch bridges, some reinforced and some prestressed, their design and construction, including falsework; examples of hollow box girder, long span bridges are included. Special types, including prestressed, suspended, and rigid frame with X- and V-shaped supports are discussed with illustrations of both actual and proposed bridges.

Kelowna floating bridge

W. PEGUSCH, *The Engineering Journal* (Montreal), V. 40, No. 4, Apr. 1957, pp. 413-421
Reviewed by ARON L. MIRSKY

The unstable bottom of Okanagan Lake in British Columbia, unsuitable even for a rock causeway, led to the selection of a floating bridge to replace the existing car ferry on B. C. Highway 97. Twelve reinforced concrete pontoons (six standard, four "superstructure," supporting a steel superstructure to permit passage of small boats, and two "transition," taking the end reactions of steel truss spans), rigidly connected together and held in line by lateral cables to concrete anchors on the lake bottom, comprise 2100 ft of the bridge project. (There is also a steel lift span.) Paper describes design and proposed construction.

Construction

SAL needed an office building fast—Lift-slab technique did the job

Railway Age, V. 142, No. 26, July 1, 1957, pp. 36-38
Reviewed by ARON L. MIRSKY

New $500,000 division office building for Seaboard Air Line at Jacksonville, Fla., built by lift-slab methods, was first railroad structure to be so constructed. Savings in time and money are claimed.

Mexico: building today

Concrete Quarterly (London), No. 33, Apr.-June 1957, pp. 2-28

Presents a review of concrete construction in Mexico including résumé of work of Felix Candela in reinforced concrete thin shell structures. Well illustrated and described principally from the architectural standpoint.

Autogenous pressure welding of reinforcing bars (in German)

G. KURSCHNER, *Bauplanung-Bautechnik* (Berlin), V. 11, No. 2, Feb. 1957, pp. 86-88
Reviewed by I. M. VIEST

Describes a machine for autogenous butt-welding of reinforcing bars. The unprepared ends of two reinforcing bars clamped into the machine are electrically heated by a two-sided heater retracted automatically after the

A part of copyrighted JOURNAL OF THE AMERICAN CONCRETE INSTITUTE, V. 29, No. 5, Nov. 1957, *Proceedings* V. 54. Address P.O. Box 4754, Redford Station, Detroit 19, Mich. Where the English title only is given in a review, the book or article reviewed is in English. If it is followed by a foreign title the work reviewed is in that language. In those cases where the foreign title cannot conveniently be set in type or is not available, the language of the original article is indicated in parentheses following the English title. Copies of articles or books reviewed are **not** available through ACI. Available addresses of publishers are listed in the June "Current Reviews" each year. In most cases ACI can furnish addresses of publications added later.

For those members who cut apart this section for pasting on cards for card indexes, a limited number of complimentary reprints of the "Current Reviews" section are available from ACI headquarters on request.

bars have reached the desired temperature. The retraction of the heater releases a trigger so that the movable head forces the molten ends of the two bars together.

It is claimed that the new machine saves about 95 percent of time necessary for other welding processes, and that it may be operated by semi-skilled workers. Tests are quoted which have shown that the welds satisfy the German requirements for reinforcing bars both as to the strength and ductility.

Pressure tunnel of the Reisach-Rabenleite pumped-storage plant on the Pfreimd (Der Druckstollen des Pumpspeicherwerkes Reisach-Rabenleite an der Pfreimd)

FRITZ HAUTUM, *VDI Zeitschrift* (Düsseldorf), V. 99, No. 5, Feb. 11, 1957, pp. 173-179
Reviewed by ARON L. MIRSKY

Description of design concepts and construction of a 1260-m length of concrete-lined pressure tunnel, completed in 1955. Lining is unreinforced and unprotected, but is prestressed by "pressure pillows" (flat jacks) inserted in slits in the crown, and by high-pressure grouting. Results, in spite of high (over 18-atmosphere) pressure and unfavorable geological conditions, showed the lining to be stable and tight.

Dams

Impressions of dam-building in Algeria (Eindrücke vom Talsperrenbau in Algerien)

F. HARTUNG, *Der Bauingenieur* (Berlin), V. 31, No. 7, July 1956, pp. 245-257
Reviewed by ARON L. MIRSKY

An illustrated survey of dam construction in Algeria over the past century. Dams of all types and ages are included, but author cautions that his study is by no means exhaustive.

Design

Nomograms for the analysis of frames

J. RYGOL, *Concrete Publications, Ltd.*, London, 1957, 53 pp., $4

Presents nomograms which are intended to reduce the calculations required for analyzing rectangular frames subjected to any system of concentrated loads linearly varying, distributed loads, or external forces. The repetitive calculations required for various trial sections in the design process are easily adapted to solution by these nomograms. The nomograms furnish nondimensional constants equal in number to the degree of indeterminacy which may be used in the complete set of formulas for moments and reactions given for each condition of loading with symmetrical and anti-symmetrical loadings included. Numerous examples illustrate application of the method.

Stress distribution in a simply-supported beam with a circular hole

J. E. GIBSON and W. M. JENKINS, *The Structural Engineer* (London), V. 34, No. 12, Dec. 1956, pp. 443-449
AUTHORS' SUMMARY

The problem of the simply-supported rectangular beam having a single circular hole is investigated for the case of bending with shear. An approximate mathematical analysis is presented along with the results of a photoelastic investigation. Results are also given for a rolled steel joist with a circular hole in its web from measurements with acoustic and electrical resistance strain gages.

The work described is part of a more extensive investigation in which beams with holes of various forms are being treated.

Elementary statics of shells (Elementare Schalenstatik)

ALF PFLUGER, Springer-Verlag, Berlin, 2nd Edition, 1957, 112 pp., $4.75
Reviewed by GUNHARD-AESTIUS ORAVAS

This introduction to the theory of thin shells by one of the prominent experts in this field constitutes, in the reviewer's opinion, the most clearly written elementary exposition on the subject in existence.

This work employs extensive verbal explanations for all the topics treated and the mathematical symbolism employed in its development. Yet it has been written for engineers and not laymen, in a sense that familiarity of the reader with fundamental knowledge in trigonometry, calculus, and mechanics are taken for granted. The subject matter has been limited to topics that do not require more advanced training.

Chapter 1 contains statement of fundamental assumptions and basic concepts upon which the thin shell theory is built. Second

chapter deals with the momentless theory (membrane theory) of thin shells of rotation. The geometrical relations, surface loads, stress resultants, fundamental assumptions of membrane state of stress, equilibrium of membrane shell of rotation, displacements at the edge of shell, and its supporting conditions are treated at considerable length. Special emphasis is placed upon the application of rotationally symmetrical membrane shells in construction of domes, tanks, and containers. In this connection spherical and conical shells are investigated under a variety of loading conditions. Analysis of containers of constant strength terminates this section.

Third chapter introduces the reader to transverse bending analysis of rotationally symmetrical shells. Geometry of deformation, stress-strain relations, stress couples and stress resultants and their relationship with the displacement of the middle surface of the shell are demonstrated. Transverse bending theory is then applied to solution of the cylindrical shell. Typical boundary conditions are discussed and the significance of the membrane solution as the first approximate stress condition is plainly pointed out. The rapidly decaying character of transverse bending from the point of origin of this disturbance is demonstrated and its application to remedy the violation of boundary deformation brought about by the membrane stresses taken as the primitive state of stress of the thin shell.

An approximate solution for the boundary bending of a thin rotational shell with arbitrary generator and its application to edge disturbance of thin conical shell terminates the chapter on transverse bending.

Chapter 4 handles the membrane stress problems of closed and open thin shells of cylindrical type. The generalized barrel shells are also investigated under typical loading conditions. Fifth chapter develops Pücher stress function method for the membrane analysis of generalized shells and its application to hyperbolic paraboloidal shells is demonstrated.

Chapter 6 treats topics of maximum stress resultants, stress couples, and the probable stress distributions that constitute these resultants. The seventh chapter is an appendix with a short bibliography on thin shell literature and an extensive collection of formulas that describe the membrane state of stress in a number of shells subjected to a variety of loading conditions.

Infinitely-long beam on elastically compressible and rotatable supports (Der unendlich lange Balken auf elastisch senk- und drehbaren Stützen)

KARL TRENKS, *Der Bauingenieur* (Berlin), V. 31, No. 7, July 1956, pp. 237-245

Reviewed by ARON L. MIRSKY

Relationships, useful in analysis of grids (on which considerable effort is being expended of late), are developed. A numerical example is included to illustrate application of the expressions.

On the analysis of the settlement of foundations in the form of a hollow circular ring (Zur Berechnung der Setzung von Fundamenten in der Form einer kreisförmigen Ringfläche)

KARL FISCHER, *Der Bauingenieur* (Berlin), V. 31, No. 7, July 1956, pp. 257-259

Reviewed by ARON L. MIRSKY

While primarily of soil mechanics interest and importance, this study yields results which are of value in design and analysis of foundations of circular towers, tanks, and similar structures where the load is uniformly distributed over the annulus of a ring. Neglecting the flexural stiffness of the ring itself, that is assuming it similar to a membrane, author determines variation of settlement along a diameter of the ring foundation. (A correction, by the author, is printed in the May 1957 issue, pp. 172-174.)

On the analysis of the tilting of foundations in the form of a hollow circular ring under eccentric loading (Zur Berechnung der Schiefstellung von Fundamenten in der Form einer kreisförmigen Ringfläche bei ausmittiger Belastung)

KARL FISCHER, *Der Bauingenieur* (Berlin), V. 31, No. 9, Sept. 1956, pp. 342-344

Reviewed by ARON L. MIRSKY

Author's earlier paper (see above) is supplemented by investigation of effect of a moment acting on foundation of form noted. This moment, in a vertical diametral plane, plus an axial load, is equivalent to an eccentric load.

Critical loads of tall building frames —Part II

R. B. L. SMITH and W. MERCHANT, *The Structural Engineer* (London), V. 34, No. 8, Apr. 1956, pp. 284-292

Reviewed by C. P. SIESS

Extension of previous paper (March 1955) to case of frames with loads applied at intermediate floor levels and with varying column sections.

Influence of creep on the shearing stresses in concrete composite structures (in German)

H. RUHLE, *Bauplanung-Bautechnik* (Berlin), V. 11, No. 2, Feb. 1957, pp. 75-78

Reviewed by I. M. VIEST

The precast and cast-in-place elements of a concrete composite beam are usually made of different concrete and at different times. Formulas for shearing stresses are presented which account for the differences in moduli of elastfcity and creep rate. The formulas are based on the assumption of uncracked sections. A numerical example illustrates the difference between the shearing stresses computed on the basis of one modulus, on the basis of two moduli, and on the basis of two moduli plus creep.

The author points out that at ultimate load the effects of deformational stresses are negligible.

Load deformations of reinforced concrete beams (in German)

R. RABICH, *Bauplanung-Bautechnik* (Berlin), V. 10, No. 12, Dec. 1956, pp. 497-503

Reviewed by I. M. VIEST

A method is presented for computing the deflections of a reinforced concrete beam for full range of loading. The method divides the deflection into three parts: (1) deflection of an uncracked member; (2) additional deflection caused by cracking; (3) additional deflection caused by yielding of steel. Expressions are derived for the first two terms; an increase of deflection without any increase of bond is assumed to follow on commencement of the yielding of steel. The method is compared with the results of two tests of simple beams and a reasonably good agreement is found at all loads. A discussion of miscellaneous items affecting the deflections of reinforced concrete beams completes the paper.

Will ultimate strength design of reinforced concrete beams simplify stress calculations?

E. M. RENSAA, *The Engineering Journal* (Montreal), V. 40, No. 6, June 1957, pp. 805-808, 840

Reviewed by ARON L. MIRSKY

Author's conclusion: *No.* He discusses many facets of the problem of analyzing the stresses in a horizontal member in bending (properties and limitations of reinforced concrete; the variability of concrete; under-reinforcing versus over-reinforcing; effects of long-term loading; use of compression reinforcement; over-reinforcing of T-beams with closely-spaced stems) and comments that ". . . it would be necessary for a designer to have a very clear understanding of the fundamental facts of reinforced concrete if he should base his design work on ultimate strength of reinforced concrete beams. There may perhaps be some doubt if all of those who now design by means of tables and formulas have this knowledge."

An interesting and informative paper, which the proponents of ultimate strength design will undoubtedly not leave unanswered.

Pressure line for a two-hinged arch rib subject to vertical loads

PAUL H. STERN, *The Trend in Engineering at the University of Washington*, V. 8, No. 2, Apr. 1956, pp. 29-31

Reviewed by ARON L. MIRSKY

Presents derivation of a general expression for the ordinate to the pressure line at any point. Two numerical examples are included.

The analysis of grid frameworks of negligible torsional stiffness by means of basic functions

LESLIE G. JAEGER, *Proceedings*, Institution of Civil Engineers (London), V. 6 (session 1956-57), Apr. 1957, pp. 735-757

Reviewed by ARON L. MIRSKY

Theory of grid frameworks of negligible torsional stiffness is generalized to remove restriction to simply supported ends, by adopting "basic functions." These, used by C. E. Inglis in analyzing the whirling of shafts, are functions $y = F(x)$ satisfying the fundamental equation $d^4y/dx^4 = \theta^4 y$, where θ is a constant.

After a brief review of the analysis of simply supported grids with negligible torsional stiffness (cf. paper by A. W. Hendry

and L. G. Jaeger, title source, Part III, V. 4, No. 3, Dec. 1955, pp. 939-971; "Current Reviews," ACI JOURNAL, Sept. 1956, p. 327), paper presents the general theory and applies it to the analysis of a grid of three longitudinal and six transverse members, the longitudinals being encastré at one end and simply supported at the other (i.e., "interconnected propped cantilevers"), and to interconnected bridge girders continuous over two equal spans. Analogy with whirling shafts is noted as affording a short-cut. Two appendices give tables of distribution coefficients, and details and tabulated values of basic functions.

Analysis of beams in space and in the plane. Theory of elastic networks (Le calcul des poutraisons dans l'espace et le plan. Théorie des réseaux élastiques)

P. BLAISE, *Annales des Ponts et Chaussées* (Paris), V. 126, No. 4, July-Aug. 1956, pp. 445-462; No. 5, Sept.-Oct. 1956, pp. 609-628

Reviewed by ARON L. MIRSKY

Author sets up topologic analogy between electric networks (Kirchhoff's method) and systems of beams in equilibrium ("elastic networks"). In second part a method, employing matrix notation, is used to analyze five hyperstatic structures, including a three-span fixed-end arch on flexible piers, and a two-story single-bay frame in which each transom is composed of two members connected at the ends only, one being convex upward, the other convex downward, giving a lenticular appearance to the transoms.

General relation between the elastic-limit stresses of a body under arbitrary loading (Relation generale entre les contraintes limites elastiques d'un corps sous des sollicitations quelconques)

L. P. BRICE, *Memoires*, Societe des Ingenieurs Civils de France (Paris), V. 109, No. 6, Nov.-Dec. 1956, pp. 517-538

Reviewed by ARON L. MIRSKY

Subtitled "Theory of critical volume of dilatation: determination of direction of shears," paper reviews briefly the various theories of failure of materials and the theory of the intrinsic curve (cf *Annales des Ponts et Chaussees*, Nov.-Dec. 1955, pp. 779-789; "Current Reviews," ACI JOURNAL, July 1956, pp. 139-140) and then presents author's critical-volume-of-expansion theory. Theory is then applied to several materials. (See also the following review.)

Discussion of paper appears on pp. 533-538 and also in the *Bulletin* of the society, 1956, No. 9, pp. (237-) 240-249.

Study of a criterion of the elastic limit of solids. Theory of critical volume of expansion. Direction of slip (Étude d'un critère de limite élastique des solides. Théorie du volume de dilatation critique. Direction des glissements)

L. P. BRICE, *Annales des Ponts et Chaussées* (Paris), V. 126, 1956: No. 4, July-Aug., pp. 423-444; No. 5, Sept.-Oct., pp. 573-608

Reviewed by ARON L. MIRSKY

Author's critical-volume-of-expansion theory, for the determination of the boundaries of the elastic domain of a homogeneous isotropic solid and the prediction and determination of the existence and direction of the slip planes, results in an equation involving the three principal stresses corresponding to any limiting state of stress. This equation is determined by either (1) any two limiting states of stress, or (2) Poisson's ratio plus one limiting state of stress (the other two preferably being zero). Experimental verification of theory was obtained from studies of sand, plastic materials (clay, lead, plastics), metals, and concretes and rocks. (See also preceding review.)

New ACI Code—its implications and ramifications

HOWARD SIMPSON, *Journal*, Boston Society of Civil Engineers, V. 44, No. 2, Apr. 1957, pp. 98-116

Reviewed by ARON L. MIRSKY

While it may smack of carrying coals to Newcastle to mention this paper in the pages of the ACI JOURNAL, it should be noted that the 1956 ACI Code contains some major changes (or should the word be *innovations*?), and that designers, particularly those to whom the requirements of the earlier editions have become second nature, require education and/or reorientation, and that it will be some time before the flow of commentaries and explanations subsides. Paper under discussion is a worthwhile contribution, particularly since it stresses precautions to be observed in applying the new code.

Analysis of creep of statically indeterminate reinforced concrete structures

K. Okada, *Memoirs of the Faculty of Engineering Kyoto University* (Japan), V. 18, No. 4, Oct. 1956, pp. 329-340

The effect of the difference in creep characteristics of the members of statically indeterminate systems on the stress distribution in these systems is analyzed theoretically. Shows that the variation and redundant forces caused by creep is particularly large for reinforced concrete indeterminate frames. Analysis follows fundamental elastic equations, theorem of three moments, slope-deflection method, and moment distribution method modified for this particular problem. Includes eight references to Japanese and German literature.

Analysis of thin-slab vault roofs (in Hungarian)

E. Dulacska, *Magyar Épitöipar*, V. 5, 1956, No. 2, pp. 87-93

Hungarian Technical Abstracts V. 9, No. 1, 1957

Taking into consideration the results obtained by the conventional exact but lengthy methods of analysis, a new practical method of approach has been developed by applying certain simplifications generally on the conservative side. The present paper deals primarily with long vaults in which longitudinal bending and torsion may be disregarded. The theoretical derivation of the method is determined by the equilibrium of the structure under the action of outer forces. The application of the method is illustrated by a numerical example.

Tables of statics—Regulations for design of buildings in timber, stone, steel, and reinforced concrete with formulas and tabulated values for different loadings (in German)

F. Boerner, edited by G. Jung, Wilhelm Ernst & Sohn, Berlin, 14th Edition, 1957, 674 pp., 52 DM (boun)

Reviewed by J. J. Polivka

Fourteenth edition of this excellent handbook is completely revised with many valuable additions, especially in chapters on strength of materials, statics, reinforced concrete, steel structures, foundations and bridges, with specifications and tables essential for current engineering practice. As the title indicates, the handbook refers basically to structural design, without detailed presentation and discussion of various construction methods and supervision. References are made only to German standard regulations and specifications.

Behavior of structures in the different stages of equilibrium (in German)

Zarmayr Migirdicyan, Reprint from *Preliminary Publication*, International Association for Bridge and Structural Engineering, 1956

Method developed by the author for the analysis of various stages of the equilibrium existing between loading conditions and energy of resistance, makes it possible to clear problems related to stability and to the different factors varying through time. It further allows to establish, on homogeneous basis, the new prestressing processes and failure calculation methods.

Designing thin shell structures

Boyd G. Anderson, *Consulting Engineer*, V. 9, No. 6, June 1957, pp. 78-84, 86

Reviewed by Aron L. Mirsky

Discusses application of thin shell and folded plate designs to short-, medium-, and long-span and monumental structures, with particular emphasis on aesthetics, utility, economics (especially costs), and such design features as lighting, acoustics, roofings, and mechanical installations. Analytics ("design") and structural action of such structures are briefly discussed. Illustrations include several awe-inspiring photographs which well demonstrate the versatility of this structural concept.

Materials

Investigation of portland blast-furnace slag cements

Technical Report No. 6-445, Waterways Experiment Station, Vicksburg, Miss., Dec. 1956, 45 pp., $0.75

Discusses properties of slags, portland cement clinkers, and portland blast-furnace slag cements and the properties of concrete made with portland slag cements using small aggregate or large aggregate. Recommendations are that portland blast-furnace slag cement complying with current federal and ASTM requirements is essentially equivalent to Type I portland cement, and that it

would be practicable to add minor chemical requirements and physical requirements to these specifications to insure that portland blast-furnace slag would be equivalent to Type II portland cement. Other recommendations are a slight decrease in the required minimum fineness, a slight increase in the requirement of air in mortar for the air-entraining type, and making the fineness requirements equivalent to those applicable to ordinary portland cements.

Requirements for water for use in mixing or curing concrete

Technical Report No. 6-440, Waterways Experiment Station, Vicksburg, Miss., Nov. 1956, 35 pp., $0.50

Discusses the problem caused by impurities in the water affecting properties of concrete. Reports results of paste and mortar, and stain tests on samples made from water having various amounts of common contaminants. Concludes that a specification of the pH does not in itself provide a basis for specifying quality of mixing water. Similarly, the quantity of dissolved solids does not provide such a basis. Suggests that the test procedures set forth in Corps of Engineers specification CRD-C 401 represent practical, workable performance tests for determining staining tendencies of curing water. The proposed revision of CRD-C 400 presents requirements for water for use in mixing or curing concrete. The report includes 25 references.

Corrosion of galvanized steel in contact with concrete containing calcium chloride

CLARENCE E. MANGE, *Preprint*, 13th Annual Conference, National Association of Corrosion Engineers, St. Louis, 1957, 9 pp.

Severe and rapid corrosion of galvanized steel sheets, used as permanent forms in the construction of concrete floor and roof slabs, has been investigated.

Calcium chloride as a cold weather admixture for concrete has been generally accepted, and use of galvanized steel sheets as permanent forms for concrete slabs has been approved on innumerable structures. The combination of galvanized steel in contact with concrete containing calcium chloride, the sealing of excess water within the slab, and the application of heat has resulted in the rusting and perforation of the metal forms.

Of primary importance in these corrosion failures is the use of calcium chloride as an admixture in the concrete.

Adhesives stronger than concrete

Concrete Construction, V. 2, No. 3, Mar. 1957, pp. 2-3
BRI ABSTRACTS
First Quarter, 1957

Field and laboratory tests by the California Division of Highways using epoxy-thiokol adhesives for the restoration of spalled and cracked surfaces of concrete. Laboratory tests indicated that the bond obtained with the use of the adhesive was stronger than the concrete beam (6 x 6 x 30 in.) used in the tests, both in the case of cementing two segments of the same beam, and cementing approximately equal lengths of new and old concrete together. Photographs are also shown of a large building restored with a commercial epoxy-based compound.

Variable cement and its effect on concrete control

D. CAMPBELL-ALLEN, *Journal*, Institution of Engineers (Australia) (Sydney), V. 29, No. 4-5, Apr.-May 1957, pp. 109-112

Statistical analysis of the effect of variations in cement on concrete strengths. Includes suggested limits on accuracy of proportioning raw materials to produce cement, and specifications by users to control variation in cement. Principal conclusions are that a price rise of up to 15 percent for more uniform cement may be justified on the basis of concrete strength achieved and that there is little prospect of reducing concrete strength variation at 28 days below a coefficient of variation of 6 percent.

Pozzolanic materials as portland cement admixtures. Part 3 (in Japanese)

SHOICHIRO NAGAI, ATSUSHI OTSUKA, and ATSUMI ISHII, *Journal of Ceramic Association of Japan* (Tokyo), V. 63, No. 715, 1955, pp. 573-579
CERAMIC ABSTRACTS
July 1957 (Yamasaki)

Four kinds of fly ash were examined by chemical and electron microscopic methods. They were tested for swelling (in water and in milk of lime), alkalinity, bending and compressive strengths, and bleeding.

Pozzolanic cements having high chemical resistance and normal hardening —applications of fly ash in the manufacture of cement (in French)

M. P. Fouilloux, *Silicates Industriels* (Paris), June 1957

A résumé of American practice in the use of pozzolanic materials, including fly ash, and French research aimed at the utilization of fly ash in everyday concrete.

Rubber and the grading of sands and other aggregates

F. E. Jones, *Rubber Developments* (London), V. 10, No. 1, Spring 1957, pp. 27-29

Describes the method of grading concrete aggregates by elutriation which separates fine from coarse, washes the material, and eliminates silt, dust, and rock flour as waste without the use of screens by passing the aggregate through a vertical current of water. Separation sizes may be easily adjusted to any desired size by changing the rubber nozzle to vary the velocity of the flow, maintaining a constant pressure.

Studies relating to the testing of fly ash for use in concrete

R. H. Brink and W. J. Halstead, *Proceedings*, ASTM, V. 56, 1956, pp. 1161-1214

Reports on an investigation of the variations in properties which may be expected and the effects of these variations on the behavior of fly ash in mortar of 34 fly ashes from 19 different sources. Strength development is related to the carbon content and to the fineness of the fly ash as measured by the amount passing the No. 325 sieve. No correlation of strength with the constituents of the fly ash was obtained. Studies also show amount of fly ash required to reduce expansion below a safe limit due to alkali aggregate reaction for the various fly ashes tested.

Use of fly ash in concrete

A. G. Timms and W. E. Grieb, *Proceedings*, ASTM, V. 56, 1956, pp. 1158-1160

A study of the properties of concrete containing fly ash as a replacement for part of the cement. Fly ash from four sources in use was investigated. The effects of fineness and carbon content upon strength at various ages, shrinkage, durability in freezing and thawing, and the resistance to the attack of ice-removal salts were tested. Tests indicate that all strengths up to the age of 28 days were lower for concrete containing fly ash as a cement replacement. After 1 year of curing, strengths of concrete containing fly ash were about as high or higher than the plain concrete. In general, fly ash was detrimental to the durability considered in terms of resistance to freezing and thawing, or resistance to the attack of ice-removal agents.

Pavements

Longton by-pass road

The Engineer (London), V. 203, No. 5288, May 31, 1957, pp. 840-841

Road construction in Lancashire: progress on the Preston and Longton bypasses

Engineering (London), V. 183, No. 4760, May 31, 1957, pp. 699-700

Reviewed by Aron L. Mirsky

Progress report and brief description, with photographs and sketch, of the construction of England's first motorways. Longton bypass, 2.56 miles long, has dual 24-ft roadways; the 26 ft wide slabs, 10 in. thick, are laid in two courses on a burned colliery shale subbase, thus putting to good use a local waste byproduct. Operations are highly mechanized, even by American standards, and over 500 lineal ft of roadway has been constructed per day. Preston bypass, on the other hand, has a flexible-type pavement.

Concrete pavements (Pavimentaciones de hormigón)

Angel Saenz de Heredia Ulloa, Instituto Tecnico de la Construccion y del Cemento, Madrid, 1957, 263 pp.

Reviewed by Celso A. Carbonell

The book deals mostly with construction of concrete pavements, however, some theoretical aspects are also presented. The operations involved in the production of concrete for pavements from the selection of aggregates to the opening of the pavements to traffic are explained with great detail.

Different kind of joints and their applications are discussed in a complete section dealing with this matter. Useful information is presented in a chapter dedicated to planning of a concrete pavement. The importance of good inspection and the ways of attaining it are also dealt with in a whole chapter.

Model analysis of pavement stresses

DON H. DANIELSON, LEON M. LA CROSS, and MARTIN EKSE, *The Trend in Engineering at the University of Washington*, V. 8, No. 2, Apr. 1956, pp. 4-7
Reviewed by ARON L. MIRSKY

Description of an ingenious device developed and constructed at the University of Washington. Features of the one-third scale test track are the straight path, the variable wheel speed, and the variable load. Provision is made for testing pavements with frozen and saturated subgrades.

Portland cement concrete in highway engineering

Engineering Institute on Highway Engineering, University of Wisconsin Extension Division, Feb. 1956, 135 pp., $2.50

Includes 14 papers discussing construction problems of concrete pavement, control of mixtures, inspection of construction, laboratory tests on concrete for paving, forming small highway structures, construction of small bridges, subgrade and subbase problems, mud-jacking, ice control, joint maintenance, bonded resurfacings, and applications of soil cement paving.

Skidding resistance of roads and the requirements of modern traffic

C. G. GILES, *Road Paper* No. 52, Road Research Laboratory, Department of Scientific and Industrial Research; *Proceedings*, Institution of Civil Engineers (London), V. 6, Feb. 1957, pp. 216-242

Investigations on the relation between skidding resistance and risk of skidding accidents are considered. The results show the skidding risks associated with different road characteristics. As a guide to meeting requirements, a table of suggested sideway-force coefficients is given. The paper concludes by considering the main characteristics of surfaces which determine their resistance to skidding.

Tests to evaluate concrete pavement subbases

L. D. CHILDS, B. E. COLLEY, and J. W. KAPERNICK, *Proceedings*, ASCE, V. 83, HW3, July 1957, p. 1297-1–1297-41

An investigation designed to aid in evaluating the contribution of subbases under concrete pavements to the strength of the roadway structure was inaugurated by load-testing concrete panels built on five different foundations. One subgrade was a 4 ft deep bed of high-bearing-value sand and gravel, a second was a low-bearing-value clay 5 ft deep, and three foundations consisted of well-compacted, dense graded sand and gravel subbases of thicknesses 3, 6, and 12 in. placed upon the deep clay subgrade.

Upon these foundations, 6-in. plain concrete slabs 10 x 15 ft were cast and instrumented to register strains in the concrete, panel deflections, and vertical pressures at the slab-subbase and subbase-subgrade interfaces. Static loads were applied to these panels at the corners, edges, and interiors. The data obtained from tests conducted when the panels were "flat," i.e. fully in contact with the supporting soil, showed the extent to which the granular subbases contributed to the strength of the pavement structure.

Suggested design for an experimental prestressed concrete pavement

E. J. COPPAGE, JR., *Roads and Streets*, V. 100, No. 8, Aug. 1957, pp. 80-82, 86-87

Describes and illustrates a proposed method for new experimental prestressed concrete pavements using fixed abutments and center jacking to eliminate prestressing steel. Details and comparative cost estimates of the proposed method are included.

Prestressed Concrete

Concrete replaces wood power poles

W. L. PILSBURY and C. B. BENHAM, *Engineering News-Record*, V. 159, No. 4, July 25, 1957, pp. 41-42

Prestressed concrete transmission line towers were used by the Florida Power Corp., St. Petersburg, Fla., in a 9 mile test study section on a transmission line between Benson Junction and DeLand, Fla.

Construction, the erection cost, and anticipated maintenance costs are to be carefully studied on the test section. To date, the prestressed poles show up very well as a substitute for wood poles. Test section towers are two 75 ft tall poles with a 39 ft cross arm, V-braces, and steel angle cross bracing below the cross arm. The concrete poles have I-shaped cross sections and are prestressed by pretensioned strands. The 51 frames installed were designed to resist transverse loads caused by 135 mph winds. The poles are pictured, design described, and cost comparisons given.

Prestressed transmission line poles (in Hungarian)

P. VAJDA, *Mélyépitéstudományi Szemle*, V. 6, 1956, No. 1, pp. 27-36

HUNGARIAN TECHNICAL ABSTRACTS V. 9, No. 1, 1957

The study reports on the development of commercially prefabricated prestressed reinforced concrete poles from 1950-1955, used as substitutes for wooden and steel structures. The poles have double the life of wooden poles and compared to steel poles insure a 70 percent economy in steel; 5 mm diameter high-tensile reinforcement is used. Detailed description is given on the 35 kv poles, on the manufacturing technology, and on the erection.

An appreciation of the work carried out on fatigue in prestressed concrete structures

R. E. ROWE, *Magazine of Concrete Research* (London), V. 9, No. 25, Mar. 1957, pp. 3-8

A review of the research on fatigue and prestressed concrete. Tests reviewed show excellent fatigue resistance in the design range of loading. Above cracking, fatigue strength of the high tensile steel is critical. Some data are available on fatigue strength of high tensile wires. No comparable figures on the fatigue strength of high tensile alloy bars. The paper concludes with suggestions for future research; eighteen references.

Some suggestions concerning the application of prestressed concrete in the German Democratic Republic (in German)

P. MLOSCH, RUNGE, THEIL and TIEDKE, *Bauplanung-Bautechnik* (Berlin), V. 10, No. 8, Aug. 1956, pp. 309-314

Reviewed by I. M. VIEST

Discussion of some current practices and developments in prestressed concrete in East Germany including detailed description of two types of prestressing steel: alloy bars and high-strength wire with ultimate strength of about 150,000 psi and over 210,000 psi, respectively. The mechanical properties include, among others, a technical creep limit and fatigue strength at the load level equal to about 55 percent of ultimate strength. The end anchorage for the alloy bar utilizes thread and nut, while the one for wires uses steel friction cones anchored into a steel plate which serves as the tensioning element for all wires of one parallel-wire cable.

Other topics included are the prestressing machinery, prestressing beds and forms for factory produced elements, and examples of applications of mass-produced units to slab and roof construction.

Up-to-date reinforced concrete sheet piles (in Hungarian)

F. HALLOSI, *Magyar Épitöipar*, V. 5, No. 5, 1956, pp. 222-226

HUNGARIAN TECHNICAL ABSTRACTS V. 9, No. 2, 1957

Two types of prestressed concrete sheet piles have been constructed. The first type has been designed solid, to be driven in the conventional manner. The second, hollow type is intended for sinking by the aid of water jets. Prestressing has been employed to prevent cracking occurring during withdrawal. Solid piles about 20 ft long have been cast with a cross section of 0.10 x 0.32 m (3.9 x 12.2 in.). Additional reinforcement at the two ends adds increased safety against injury. Piles can be re-used two or three times. Hollow piles 7 m (23 ft) long having a cross section of 0.15 x 0.30 m (5.9 x 11.8 in.) have been driven to an average depth of 5.0 m (19.7 ft) into gravelly sand soil in 6 to 7 min utilizing a water jet of 0.5 m per sec velocity. These piles can be re-used six or eight times.

Properties of Concrete

Measurement of creep of mortar under fully controlled conditions

A. M. NEVILLE, *Magazine of Concrete Research* (London), V. 9, No. 25, Mar. 1957, pp. 9-12

Suggests that the chemical composition of cement is a factor in the creep of mortar. A new loading apparatus for measurement of creep is described in the results of tests with different cements presented.

Mixing proportions for concrete of plastic consistency (Composition des betons de consistance plastique)

I. LEVIANT, *Construction* (Paris), V. 11, No. 8, Aug. 1956, 3 pp.

A graphical method for determining the mix proportions to produce a plastic concrete with a desired water-cement ratio (strength) from any aggregate with a given grading.

Measurement of concrete consistency with the "Vebe" apparatus (in Serbian)

S. Bizic, *Naše Gradevinarstvo* (Belgrade), V. 11, No. 2, 1957, pp. 210-212

Reviewed by J. J. Polivka

Author discusses disadvantages of slump tests, especially in cases of low water-cement ratios, which can be avoided by using Vebe consistometer based on the energy consumed in the process of the modification of the primary mass of concrete into the final form. Sensitivity and accuracy of the apparatus is demonstrated by numerical examples.

Diffusion lengths of thermal neutrons in portland cement concrete

A. Salmon, *Report*, R/R, Atomic Energy Research Establishment, Harwell, England, 1956; *Building Science Abstracts*, V. 29, No. 11, Abstract No. 1827, Nov. 1956

Highway Research Abstracts
July 1957

The diffusion length of thermal neutrons in portland cement concrete has been measured to provide fundamental data for shielding studies. The composition and environment of the concrete was measured and is noted. The determined value of the diffusion length was (7.30 ± 0.2) cm. The density of the concrete was (2.23 ± 0.02) g per cu cm. The diffusion length was thus (7.04 ± 0.21) cm at a density of 2.3 g per cu cm.

Proportioning of concrete of specified properties with the help of fineness area (in German)

A. Pawlowitsch, *Die Bautechnik* (Berlin), V. 33, 1956

Part I—Fineness area

No. 7, July 1956, pp. 234-239

Part II—Density of concrete

No. 10, Oct. 1956, pp. 351-355

Reviewed by J. J. Polivka

Fineness modulus introduced by Abrams in 1918 is based on U. S. sieves; for this reason Hummel proposed (1951) for typical gradation of concrete aggregates the "fineness coefficient" which can be determined with any size of testing sieves. Author presents certain modifications of this coefficient which permit easy computation of average grading of the mix and exact relation to the Abrams' fineness modulus. Author calls this coefficient "fineness area" (*Kornungs-flache*). It determines also the consistency, proportions expressed in terms of weight and solid volume, and is useful for determination of various stages of concreting. For comparison of Abrams' and Hummel's coefficients charts are drawn for plotting aggregate gradings with abscissas expressing the sieve sizes in logarithmic values and retained percentages as ordinates. The fineness coefficients are then equal to the respective area (fineness area), not only for the total but also for partial grading (grading coefficients in individual stages of mixing). Numerical and geometric interpretation of various relations, applied to examples and tabulated results, serve for better clarification of the modified fineness coefficients.

Part II discusses standard definition of the density of concrete and derives formula for determining the density of fresh concrete. This empirical formula is checked by tests with good results. On the basis of introduced values for variable cement content and grading, the degree of consistency and density is calculated and presented in diagrams. Furthermore characteristics of various mixes are thoroughly discussed and expressed by formulas. Knowing all these factors it is then easy to predict compressive strength of any type of concrete at a given time. Author's derivations are compared with Feret's formula and with test results of Talbot, Richart and Suenson. Applications of author's derivations will be discussed in Part III and Part IV of the paper.

Influence on strength of the composition of concrete (Hållfasthens beroende av sammansättning hos betong)

Per Nycander, *Meddelande* 121, Statens Provningsanstalt, Stockholm, 1956, 16 pp.

Reviewed by Carl H. Gustafson

The strength of concrete is not only dependent upon the water-cement ratio, but also upon the aggregate gradation, the aggregate-cement ratio, the particle shape, and air content of the concrete. Curves are presented to substantiate each of the above statements. The end result is that the strength is a function of the water-cement ratio provided that the aggregate has approximately optimum specific surface area.

The air content affects the strength of concrete whose composition is otherwise given, in accordance with the following formula, where the air content L in the spaces is $L = l/(l + c + v)$ and l, c, and v are the

absolute volumes of air, cement, and water in a mix:

$$\frac{K_1}{K_2} = \frac{1 - 2L_1}{1 - 2L_2}$$

K_1 and K_2 are the strengths for air contents in the spaces of L_1 and L_2 respectively. Thus if the strength is known for one air content, then it can be calculated for another arbitrary air content.

Tests of concrete containing portland blast-furnace slag cement

WILLIAM E. GRIEB and GEORGE WERNER, *Public Roads*, V. 29, No. 10, Oct. 1957, p. 227

Discusses the preliminary results of research undertaken by the Bureau of Public Roads' laboratory. The tests reported here are being continued, and it is contemplated that a final report will be prepared in 1958.

In general, the tests show good results for the portland blast-furnace slag cements. Air-entrained concretes containing portland blast-furnace slag cements give lower compressive and flexural strengths at curing ages of 3 and 7 days, equal strengths at 28 days, and higher strengths at 90 days than comparable concretes containing portland cements.

Correlation of sonic properties of concrete with creep and relaxation

T. S. CHANG and C. E. KESLER, *Proceedings*, ASTM, V. 56, 1956, pp. 1257-1272

Presents a method of relating properties of concrete measured by sonic testing to creep behavior in compression and flexure. A simple procedure is also developed to relate the creep of one concrete beam to another under different loading. The results thus provide a means of predicting creep and relaxation behavior of concrete from a relatively simple sonic test.

Effects of revibration on properties of portland cement concrete

D. H. SAWYER and S. F. LEE, *Proceedings*, ASTM, V. 56, 1956, pp. 1215-1228

Repeats the work and confirms the conclusions of Tuthill and Davis reported in "Over-Vibration and Revibration of Concrete" (ACI JOURNAL, Sept. 1938, *Proc.* V. 35, pp. 41-48), without reference to or comparison with the earlier paper. An interesting new finding was that revibration does not change durability of air-entrained concrete significantly, while the durability of non-air-entrained concrete is critically decreased.

Content of water in fresh concrete (Betongens vattenhalt)

PER NYCANDER, *Meddelande* 119, Statens Provningsanstalt, Stockholm, 1956, 16 pp.

See also:

P. NYCANDER, *Beton* (Berlin), V. 41, No. 2, 1956, pp. 107-121; *Building Science Abstracts*, V. 30, No. 1, Jan. 1957, p. 5

Reviewed by CARL H. GUSTAFSON

A discussion of the water content of concrete. If the required water content is greater than that indicated by the curves in this bulletin, then there is reason to suspect that the particle shape of the aggregate or parts of it is unsuitable. Another reason may be the cement content, sand, or gravel.

A concrete of given consistency and maximum size of aggregate with the lowest possible water content is best as regards strength, impermeability, frost resistance, small volume change on drying, low elastic deformation and plastic flow, but its greatest advantage lies in its workability, which in turn means a uniform and therefore good final product.

Structural Research

Failure test of a reinforced concrete with LU3 steel, cantilevered canopy (Prova a rottura di una pensilina in calcestruzzo armato con acciaio sagouiato LU3)

MARIO CAIRONI, *Giornale del Genio Civile* (Rome), V. 95, No. 3, Mar. 1957, p. 186

Reviewed by JOHN I. PRELEZ

Refers to a stress test on a cantilevered concrete canopy, reinforced with LU3 steel. Author compares the failure experienced under the test with stress moments calculated by methods of other authors. Comparison between theory and practice.

Experimental study of double curve shell roof (Studio sperimentale del comportamento di una volta sottile a doppia curvatura)

FRANCO LEVI, *Giornale del Genio Civile* (Rome), V. 95, No. 3, Mar. 1957, p. 163

Reviewed by JOHN I. PRELEZ

Describes design of a doubly curved shell roof and the four concrete trusses on which

it is supported, and gives the static reactions (deformations) at all critical points under different load conditions.

Determination of the degree of adhesibility of prestressed concrete insets to superimposed concrete (in Polish)

W. Grzegorzewski, *Inzynieria i Budownictwo* (Warsaw), No. 2, 1956, pp. 69-71
Polish Technical Abstracts No. 2 (26) 1957

In designing reinforced concrete in which fresh concrete is superimposed on prestressed concrete planks it has appeared necessary to test adhesion between the concrete already set and that freshly laid on. Tests were made with beams of such a cross section as would cause the beam tested to break at a desired point, i.e., on the interface between the two concrete layers. In order to eliminate the possibility of lamination, a number of beams were made with insets with protruding anchorages. A number of the insets were grouted in with the upper surface remaining uncoated; in others, the surface was coated with a layer of paraffin. The tests made have not yet furnished a conclusive basis for determination of adhesion. The following factors have so far been analyzed: the effect of the degree of prestressing; the effect of moistening the insets with water; and the effect of coating them with cement grout. Prestressing the insets in a higher degree makes higher stresses permissible as regards lamination. Moistening the insets with cement grout, as compared with moistening them with water, has a more positive effect resulting in a higher adhesibility of both the concrete layers.

Plasterene model as structural design aid

P. S. Balint, *Constructional Review* (Sydney), V. 30, No. 4, Apr. 1957, pp. 24-28

Describes a model technique which may be used to supplement the structural design and analysis of slabs and complex structures. A new modeling material is employed—plasterene polyester resin. It may be molded in its liquid form but will later harden, showing characteristics of a homogeneous, elastic material with a Poisson's ratio about the same as that of concrete.

On the problems of vibrations of concrete structures (in Polish)

Z. Wasiutynski, *Inzynieria i Budownictwo* (Warsaw), No. 4, 1956, pp. 162-166
Polish Technical Abstracts No. 2 (26) 1957

Fatigue tests made with concrete showed that concrete subjected only to compressive stresses within permissible limits in accordance with codes is resistant to vibrations. The tests justify the assumption that prestressed constructions are resistant to vibrations within the limits of permissible static stresses, provided that such constructions are completely prestressed and faultlessly executed, and that the materials used are homogenous.

Behavior of one-story reinforced concrete shear walls

Jack R. Benjamin, Harry A. Williams, *Proceedings*, ASCE, V. 83, ST3, May 1957, pp. 1254-1–1254-49

Paper gives the results of an investigation of one-story plain and reinforced concrete shear walls subject to shear forces applied in the plane of the wall. Panel proportions and reinforcing, and column proportions and reinforcing were investigated.

Some approximate relationships are suggested as a means of predicting the load-deflection curves for these walls.

Investigations on hinges of reinforced concrete (Untersuchungen über Federgelenke aus Stahlbeton)

Karl Kammuller and Ottfried Jeske, *Bulletin* No. 125, Deutscher Ausschuss für Stahlbeton (Berlin), 1957, 30 pp., 10 DM
Reviewed by Aron L. Mirsky

Reports a thoroughgoing investigation of the stresses in hinges of Mesnager* type in reinforced concrete structures such as arches and rigid frames. Theoretical studies are briefly noted; the major portion of the work discussed was done on photoelastic models and on full-size concrete hinges. Results proved a known fact: the concrete in such hinges, although stressed to very high levels, was able to "take it"; hair-cracks could not be completely prevented but were not dangerous and did not weaken the hinge. A brief set of rules for practical application of the results is given.

*This name, and that of Considére, do not seem to be mentioned in the text. Instead, more recent works by Maillart, Freyssinet, and other are cited.

Some observed strain phenomena of a post-tensioned concrete beam under prestress and flexure

B. L. Dutton, *Proceedings*, Society for Experimental Stress Analysis, V. 14, No. 1, 1956, pp. 47-52
Applied Mechanics Reviews
August 1957

In a laboratory conducted test on a post-tensioned concrete beam, SR-4 strain gages and a Cox and Stevens electrically actuated weighing unit with capsule inserted between a hydraulic jack and the beam were the instrumentation devices used in measuring stress-strain phenomena under cycle of prestressing.

Plastic flow in the concrete and apparent strain-consolidation of the concrete crystalline structure were evident from the observations. Under both prestress and flexure loadings, variation in elastic moduli, deflection, and camber were of interest.

Included are data on strain in upper and lower fibers, camber under prestressing load, and deflection and elongation of prestressed wire under flexural loading.

General

Architecture as space—How to look at architecture

Bruno Zevi (translated by Milton Gendel, edited by Joseph A. Barry), Horizon Press Inc., New York, 1957, 288 pp., $7.50
Reviewed by J. J. Polivka

Value of the book is best expressed by Frank Lloyd Wright: "Bruno Zevi is the most penetrating and outspoken critic of our time. He has the faculty of seeing architecture, seeing into it to its essence, and stating what he sees in revealing and courageous terms."

Principles of space structures have been best expressed during the last decades by new structural types such as domes, all kinds of three-dimensional shells, conoids, hyperbolic paraboloids; new structural materials such as prestressed concrete, aluminum alloys, glue-laminated wood; and by improved, novel construction methods, such as precast concrete assembled to volumetric schemes, etc. For this reason, Zevi's review and thorough presentation of buildings in ancient Greece and Rome, and of other Gothic, Renaissance, and Baroque structures, tracing space concepts through the ages up to organic architecture of today, are of great interest not only to architects but also to structural engineers. Especially engineers applying the new methods of structural analysis and new materials can be inspired in their designs by philosophical ideas and criticism of the internationally known author.

Methods of foundation engineering (in Czech)

Bazant Zdenek, Jr., Czechoslovak Academy of Science, 1956, 548 pp.
Reviewed by J. J. Polivka

Very good and complete book being used in author's classes at Prague Technical University and by professional engineers, written on the basis of his 25-year practical experience and study of foundation problems. Many references to research and publications of his predecessor, B. Tolman. Book concentrates on foundation methods commonly used today, and their development. Theoretical part and practical applications are subjects of another volume in preparation. Special emphasis is given to mechanization and economy, often overlooked in similar publications. Book is valuable not only for designers but also for builders and supervising engineers. Author invites the readers to submit suggestions for revisions and additions to be considered in the next edition. Reviewer believes that more thorough description should be given intrusion and prepacked methods. Also chemical soil solidification should be presented more thoroughly.

Reinforced concrete structures (Stahlbetonkonstructionen)

K. W. Sachnowski (Sakhnovski), VEB Verlag Technik, Berlin, 1952, 846 pp., 61 DM
Reviewed by Gunhard-Aestius Oravas

A German translation of the seventh edition of the Russian original that is used in Soviet universities as a text book. General character of this work lies in an effort to present the design and construction of reinforced concrete structures within the limits of the Russian building code (ZNIPS). The reviewer was surprised to learn that all reinforced concrete design in Russia has been based on ultimate strength principles as far back as the year 1938.

Theoretical parts of this treatise are elucidated by succinct but adequate numerical examples. Explanations on construction and other details of reinforced concrete are quite extensively covered, more so than in similar

text books of western countries. The properties and behavior of concrete receive a generous discussion. The work also contains short instructions for simplified design of structural members like thin shells, plates, bunkers, silos, folded plates, frames, footings, stacks, arches, flat slabs, beams, various floor systems, columns, retaining walls, hinges and wind load design.

Appendix gives tabular values for continuous beams, plates, footings, crane loadings and data on reinforcing steel.

In addition there are illuminating sections on prestressed concrete, precast concrete construction (in this phase of construction they seem to have quite a bit of experience due to the extremely poor quality of field labor) and general strengthening techniques on damaged existing concrete structural elements.

The work covers in some detail: properties of concrete, reinforcing steel, and their interaction; principles of calculations and ultimate strength in application to design of structural members; calculation of crack formation by elastic and ultimate theory; shear stress analysis and reinforcing by conventional and cracked stage method; construction and design of floor systems; eccentrically and concentrically loaded (compression and tension) structural members; members stressed by torsion or torsion-bending; calculation of the deformation of structural members by the theory of opening crack pattern; and the design of concrete structures with stiff reinforcing.

The author of this book accords only the following non-Russians the courtesy of being mentioned when essentially their contributions are discussed: Considére, Dischinger, Freyssinet, Hennibique, Lewe, Marcus and Mörsch.

The concept of rectangular compressive stress distribution in the ultimate design of concrete beams subjected to simple bending is ascribed to a Russian, Loleit; yet it has been well known for some 45 years that E. Suenson originated this approach in 1912. The yield-line theory of design of plates is ascribed to a Russian engineer, Gvosdyov; yet this theory has been in existence some 35 years since the publication of papers by A. Ingerslev in 1921 and K. W. Johansen in 1931.

Rail stool for anchoring track layouts on concrete structures (Der Schienenstuhl zum Befestigen von Gleisanlagen auf Betonbauwerken)

A. Grossmann, *VDI Zeitschrift* (Düsseldorf), V. 99, No. 7, Mar. 1, 1957, pp. 297-298
Reviewed by Aron L. Mirsky

Abstract of article by J. Storcks in *Stahl und Eisen*, V. 75, 1955, pp. 1784-1787.

Anchoring frogs and similar trackwork directly to concrete bridge decks and suchlike structures through rail chairs does away with the usual ballast bed and its problems; the long life and other advantages of this method outweigh the disadvantage of the high initial cost.

Religious buildings for today

J. K. Shear (Editor), F. W. Dodge Corp., New York, 1957, 183 pp., $7.50

A philosophical discussion of the architectural problems and opportunities in church design. Discussion is supplemented by 302 illustrations, case studies, interior and exterior, of many outstanding churches. Text includes contributions from leading secular authorities, clergymen of many faiths, and architects.

Shelter structures for protection against atomic explosions (Schutzbauten gegen Atomexplosionen)

Hermann Leutz, *VDI Zeitschrift* (Düsseldorf), V. 99, No. 18, June 21, 1957, pp. 809-812
Reviewed by Aron L. Mirsky

Construction against pressure effects and against harmful radiation, and air supply, are the main items discussed. The reinforcement for the base slab of such a shelter is illustrated; even to the untrained eye it speaks louder than words.

NOTE

Copies of books and articles reviewed are not available from ACI. Available addresses of publishers are listed in the June "Current Reviews" each year. In some cases ACI can furnish addresses of publications added later.

Formation of ducts in concrete

F. E. Jones, *Rubber Developments* (London), V. 10, No. 1, Spring 1957, pp. 2-6

Describes the formation of core spaces and ducts in concrete using pneumatic duct formers. Inflatable rubber tubes are used to produce hollow concrete piles, precast lighting columns, core-lightened floors for bridge decks and buildings. Sizes used have ranged from a few inches to contain prestressing tendons in prestressed concrete to 87 in. diameter tubing used to cast in place reinforced concrete pressure pipe.

Compaction of concrete by vibration

J. M. Plowman, *The Engineer* (London), V. 203, No. 5288, May 31, 1957, pp. 830-832
Reviewed by Aron L. Mirsky

Paper covers continuation of research described in previous paper by same author (*The Engineer*, Feb. 26, 1954, pp. 302-303; "Current Reviews," ACI Journal, Oct. 1954, p. 216): (1) A second type of accelerometer is described; it consists of a polarized barium titanate disc clamped between the body of the accelerometer and a brass weight by a spring, and is more reliable and rugged, and can withstand higher accelerations, than the accelerometer previously used. (2) With additional accelerometers available, a series of tests was made to confirm the distribution of acceleration assumed and reported, on the basis of a smaller number of points, in the previous paper for a beam of rectangular cross section. (3) Tests were made using electromagnetic form vibrators as well as vibrating tables; with a form vibrator on one side only, the distribution of acceleration was markedly unsymmetrical. (4) Tests were also made using immersion (poker) vibrators. The investigation is continuing.

Concrete technology

F. S. Fulton, The Concrete Association, Johannesburg, South Africa, 1957, 515 pp.

A handbook of concrete technology similar to that prepared by the United States Bureau of Reclamation. The book is comprehensive, reliable, and up-to-date. Principal subjects included are properties, tests, and processing of concrete materials; concrete proportioning; properties of fresh and hardened concrete; suggested architectural specifications including statistical evaluation based upon criteria prepared by both the British Standards Institution and the American Concrete Institute; design of forms for concrete; concrete control; and concrete construction.

Earth pressures and retaining walls

W. C. Huntington, John Wiley & Sons, Inc., New York, 1957, 534 pp., $11.50

Intended to bridge the gap between practical design of retaining walls and that part of soil mechanics dealing with earth pressures and foundations. Using only engineering mathematics, all common cases of design of retaining walls and most special conditions encountered are covered. Devises formulas for use, gives typical designs and tabulated computations, discusses limitations and approximations involved, includes coefficients for use with common backfill materials, gives special consideration to the design of counterfort walls. The author gives a fairly complete treatment of the "trial wedge" method for computing earth pressures, showing how to use this largely nonmathematical technique both analytically and graphically. Of particular assistance in studying derivations and formulas given are the numerous figures illustrating earth pressure, conditions of instability, etc. The book should be particularly useful for a practicing structural engineer.

Scientific research and development work for the building industry in the ZNIPS Institute (Moscow) (in German)

E. Lewicki, *Bauplanung-Bautechnik* (Berlin), V. 10, No. 11, Nov. 1956, pp. 441-447
Reviewed by I. M. Viest

Describes briefly some of the facilities and work in progress at the Central Research Institute for Building Industry in Moscow including sections on lightweight concrete, autoclave curing, durability of concrete, cements, fire resistance of concrete, reinforced concrete, prestressed concrete, winter concreting, vacuum concrete, welding of reinforcing bars, lighting, acoustics, heating and ventilating.

Particularly interesting is the description of expanding cements; one starts expanding before the concrete has hardened and the other starts expanding after the concrete has hardened. The second type is used for prestressed concrete.

ACI News Letter

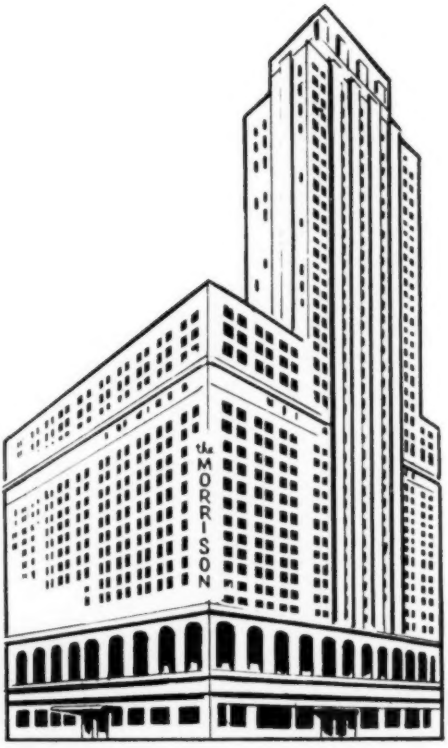
Vol. 29, No. 5 JOURNAL of the AMERICAN CONCRETE INSTITUTE November 1957

Castelo do Bode Dam

The 54TH Annual ACI Convention

Feb. 24-27, 1958

the **MORRISON** *hotel*



A Variety of Topics—Covered in Eight Sessions

- Construction
- Research Session
- Structural Design
- St. Lawrence Seaway
- Fatigue of Concrete
- Proposed ACI Standards
- Design of Highway Pavements

FEB. 24-27, 1958

MORRISON HOTEL, Chicago

ACI

News Letter Contents

November 1957

On the Cover—Castelo do Bode Dam and powerhouse on the Zezere River, near Tomar in Portugal, completed in 1951. Gravity arch dam of constant radius is 378 ft high, contains some 560,000 cu yd of concrete. Associated contractors for the construction were Moniz da Maia, Duarte & Vaz Guedes, Lda., and Conrad Zschokke. Consulting engineers were A. Coyne and the Technical Department of Hidroelectrica do Zezere.

—*Photograph courtesy Laboratório Nacional de Engenharia Civil, Lisbon*

Four Technical Committees. 3

ACI Headquarters—Finishing touches on concrete roof..... 4

Committee Appointments.. 7

Positions and Projects..... 9

Form Liners.....15

Concrete Pace Setter.....17

Who's Who.....23

E. G. Swenson.....23
J. C. Saemann and G. W. Washa.....23
K. E. McKee and E. I. Fiesenheiser.....23
William Shelson.....24
Sam Hasid.....24

Honor Roll.....25

Errata.....26

New Members.....29

Tools, Materials, Services..31

Looking Ahead.....32

List of Advertisers.....34

ACI directors act on four

technical committees

Two old technical committees were reactivated, and two new ones authorized by the ACI Board of Direction at its November meeting in Seattle. New committees will work on foamed concrete and deflection of concrete building structures, while reactivated ones include Committee 322, Design of Unreinforced Concrete, and Committee 805, Application of Mortar by Pneumatic Pressure.

Deflection of buildings

The new Committee 335, Deflection of Concrete Building Structures, will study available research on deflection of concrete flexural members under rapid and long-term loads to develop recommended methods for predicting such deflections. Suggested limits for allowable deflection of various structures under given types of load will be developed. Field and laboratory research results will be studied, including the effect of the following factors: aggregates, both lightweight and normal; high strength concretes; precasting plant curing procedures; age and drying; continuity; amount, type, and location of reinforcement; prestressing; and composite action of precast with cast-in-place construction.

Foamed concrete

Newly organized Committee 623, Specifications and Practice for Foamed Concretes, will prepare recommendations for use of foamed concretes, including the specifications for materials and construction upon which the recommendations are based. Secondary standing assignment of the committee will be to furnish information on special properties of foamed concretes for use by Committee 213, Properties of Lightweight Aggregates and Lightweight Aggregate Concrete.

Unreinforced concrete

Committee 322, Design of Unreinforced Concrete, has been reactivated to review the report of the original committee published in 1942, to revise and expand it, ultimately developing a standard

Continued on p. 10

Finishing touches on

EXTERIOR WORK on ACI's new headquarters in Detroit has advanced rapidly in recent weeks as the end of the dependable-weather construction season approaches. Parking lot, driveway, and footings for the "garden" wall were concreted as finishing touches developed on the unique folded plate roof. As soon as the four special end sections of the precast roof were set in place above the corridor bearing walls, welding to provide continuity in the assembled roof began. Metal plates embedded in the edges of each roof section were joined to provide transverse moment connection—welds being spaced about 8 in. on centers. Welding was continuous on overhanging portion of the roof from window line to outer edge of slabs. Main reinforcing was also welded at the center of the building, joining each pair of roof segments at the center line.

When welded connections had established structural unity of the roof slab, adjustable shoring which had temporarily supported it was removed to leave the roof cantilevering into space as shown in the picture opposite. Engineers on hand to observe movement of the roof as it first supported its own weight reported deflections at the wall line ranging from $\frac{1}{8}$ to $\frac{3}{8}$ in., with the average about $\frac{1}{4}$ in. Average 28-day strength of the roof concrete was 5060 psi. Welded connections along the roof center line tested an average of 53,800 psi.

Embeco nonshrink mortar, a product of Master Builders Co., was used to grout between roof sections, encasing the welded transverse moment connection; it was also used for grouting between wall and deep beam of roof section, and across the gap between precast roof sections above the central hallway as photographed below. At the time of decentering, the last grout

Last roof section is hoisted into place. End members of the 4 in. thick folded plate were different in design from the other precast cantilevered roof sections

Peaks and valleys seen from above the completely assembled roof. Worker begins spraying on the white vinyl plastic roof coating which was applied in five layers

ACI concrete roof

now completed

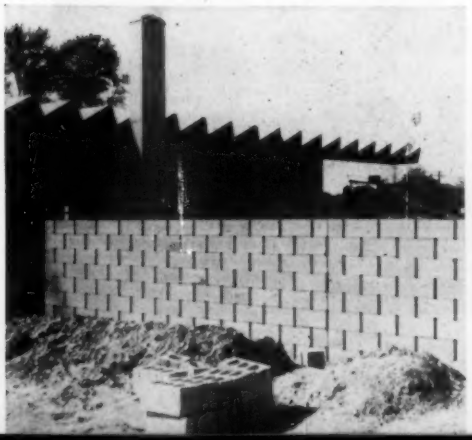
in the center was 7 days old and tested 4960 psi; 28-day strength of this grout was established by test as 6100 psi.

A nonmeltable mastic, Igas joint sealer made by Sika Chemical Corp., has been used to fill the joints on the under side of the roof from the edge of overhang to the window line. The mastic forms a continuous watertight seal between the hardened concrete members.

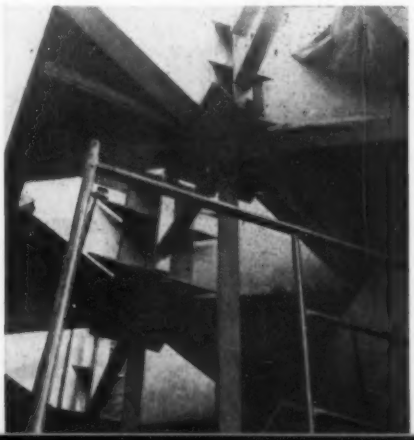
Brightness of the roof silhouette has been emphasized by 40-mil thickness of vinyl membrane coating sprayed on in five layers by Ben T. Young Co., Detroit. The plastic coating material is Secoton Hi-Build (Surface Engineering Co. product).

Continued on p. 6

Vertical masonry joints of parking lot wall, 1 in. wide, were raked 1 in. deep to give patterned effect. Control joints are spaced every 20 ft along the wall



Roof panels were joined to form X-beams over the central corridor. Forms are in place here for casting the short connecting member in nonshrink mortar



ACI Building Story . . . .

Continued from p. 5

Basement partitions, parking lot wall

Exposed masonry partitions in the basement have been completed with autoclaved slag block and brick supplied by John A. Mercier Brick Co., Dearborn, Mich. Partition thicknesses are 8, 6, and 4 in.

Autoclaved standard 8 x 8 x 16-in. slag block were used for the masonry wall surrounding the parking lot (picture at the beginning of the story). Shadow pattern in harmony with the garden wall which will be erected around the main building was secured by using 1 in. wide vertical joints raked 1 in. deep. Control joints are spaced about every 20 ft along the wall, and a precast coping will finish its top.

Paving for parking lot

Driveway and parking lot paving with roll curbs have been concreted, and a white curing compound applied. Progress picture below indicates the alternate strip concreting method used.

Local committee contributions boost ACI building fund

The Milwaukee local committee for the Institute's 1955 annual convention recently contributed cash on hand to the ACI building fund, bringing the total of such local committee contributions to nearly $5000. Funds received from the 1953 convention committee in Boston, the 1954 convention committee in Denver, the local Philadelphia committee for the 1956 convention, and the 1957 convention committee in Dallas are included in the total.

Building Committee Report

as of September 30, 1957

ACI Building Committee shows the following contributions to the ACI Building Fund by categories as of Sept. 30, 1957:

Cement producers	$ 71,612.00
Reinforcing steel industry	40,000.00
Engineers and architects in private practice	34,176.22
Contractors	18,445.00
Ready-mixed concrete and aggregate industry	12,533.87
Membership at large	7,958.14
Admixtures manufacturers	7,458.93
Concrete machinery and specialty products	3,585.00
Concrete products manufacturers	2,570.00
Special contributions	1,766.43
Eastern Canada	1,496.90
Total	$201,602.49
Pledges in hand	7,735.00
GRAND TOTAL	$209,337.49

Screeding fresh concrete in the alternate strip paving operation on ACI parking lot. In the background are other paving strips in varying stages of completion and curing

ACI technical committee appointments

Listed below are committee members recently appointed to several of the Institute's technical committees. Included are *new* appointments only.

Committee 115, Research

William A. Cordon
Utah State Agricultural College
Logan, Utah

Rudolph C. Valore, Jr.
Texas Industries, Inc.
Dallas, Tex.

Committee 116, Nomenclature

A. Amirikian
Bureau of Yards and Docks
Washington, D. C.

H. F. Clemmer
Government of the
District of Columbia
Washington, D. C.

William A. Cordon
Utah State Agricultural College
Logan, Utah

D. W. Lewis
National Slag Association
Washington, D. C.

James R. Libby
Freyssinet Co.
New York, N. Y.

R. G. Morris
Beaver Advanced Corp.
Elwood City, Pa.

L. H. Tuthill
California State Department of
Water Resources
Sacramento, Calif.

I. L. Tyler
Portland Cement Association
Chicago, Ill.

Rudolph C. Valore, Jr.
Texas Industries, Inc.
Dallas, Tex.

Committee 201, Durability of Concrete in Service

Frank H. Jackson
Consulting Engineer
Chevy Chase, Md.

Committee 214, Evaluation of Results of Compression Tests of Field Concrete

V. D. Skipper
MacDougald-Warren, Inc.
Atlanta, Ga.

Committee 315, Detailing Reinforced Concrete Structures

S. B. Larsen
Bureau of Public Roads
Washington, D. C.

Committee 323, Prestressed Reinforced Concrete (Joint ACI-ASCE)

William Dean
Florida Highway Department
Tallahassee, Fla.

G. S. Paxson
Oregon State Highway Department
Salem, Ore.

Emerson Ruble
Association of American Railroads
Chicago, Ill.

Committee 328, Limit Design (Joint ACI-ASCE)

George Winter
Cornell University
Ithaca, N. Y.

ERRATA—Title No. 51-32

"Design of Blast Resistant Construction for Atomic Explosions"

By C. S. Whitney, B. G. Anderson, and E. Cohen

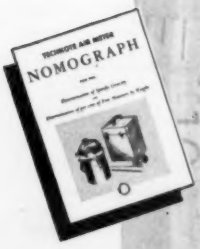
ACI JOURNAL, March 1955, *Proceedings* V. 51

AVAILABLE WITHOUT CHARGE from ACI Publications Department

PRECISION BUILT for UNEQUALLED PERFORMANCE

Tolerances held to .0005"

The **TECHKOTE AIR METER** gives by far the most dependable accuracy obtainable—and does it for the reason that the unit itself is precision-built from start to finish. The extremely close tolerances combined with rugged construction assures long lasting accuracy both in the laboratory and field. Simplified design makes for quick operation and easy maintenance.



The Air Meter combined with the outstanding and exclusive TECHKOTE NOMOGRAPH gives a highly diversified and complete concrete engineering unit.

TECHKOTE COMPANY

INCORPORATED

600 LAIRPORT STREET, EL SEGUNDO, CALIFORNIA

Positions and Projects

ASTM committees to meet in Mexico

For the first time in the history of the American Society for Testing Materials, meetings of ASTM technical committees will be held in Latin America. Committees C-1 on Cement and C-9 on Concrete and Concrete Aggregates will hold their fall meetings in Fortin de las Flores, Mexico, Dec. 2-6, 1957. Both of these committees have members from Mexico.

Arrangements for the December meetings have been made by Alton J. Blank, general manager, Cementos Atoyac, S.A. and Cemontos Veracruz, S.A., Puebla, Mexico.

Blume announces new firm

John A. Blume, consulting structural engineer of San Francisco, has announced the new firm name of John A. Blume & Associates, Engineers, and expansion to larger facilities. Associates of Mr. Blume in the new venture are H. J. Sexton, J. P. Nicoletti, R. P. Sharpe, D. M. Teixeira, and A. I. Flaherty.

Modular building standards group organized

Four leading building industry groups have joined forces in organizing the Modular Building Standards Association to boost acceptance of a program designed to hold down building costs through adoption of a basic unit of measurement.

The movement for the promotion of modular standards, or modular measure, began in 1935 when the National Bureau of Standards of the U. S. Department of Commerce proposed a project for coordinating building material sizes. Subsequent activities in this direction have been closely identified with the American Standards Association. Increasing interest in modular standards on the part of architects, general contractors, home builders, and producers of materials led to organization of the new association which was incorporated July 15, 1957. Sponsoring groups are: American Institute of Architects, Associated General Contractors of America, National Association of Home Builders, and Producers' Council, Inc. C. E. Silling, Charleston, W. Va., architect and chairman of the American Standards Association's committee which deals with coordination of dimensions of building materials and equipment, was elected president of the new group.

Prestressed concrete short course

The University of Florida's civil engineering department and the Prestressed Concrete Institute will cooperate in conducting a prestressed concrete short course, Jan. 27-31, 1958, at Daytona Beach.

Outstanding engineers from all over the country will discuss specifications, standardization, quality control, and the design of bridges, industrial buildings, lift slabs, and unusual structures, according to course supervisor A. M. Ozell, University of Florida. Lectures on design of continuous beams, composite beams, and ultimate strength design are also anticipated. A field trip to a casting yard in the area is also planned to acquaint the registrants with the manufacturing methods employed in the production of prestressed concrete products.

PROFESSIONAL CARD

JACKSON & MORELAND, INC.
Engineers and Consultants
DESIGN AND SUPERVISION OF CONSTRUCTION
REPORTS—EXAMINATIONS—APPRAISALS
MACHINE DESIGN—TECHNICAL PUBLICATIONS
BOSTON NEW YORK

Ford, Bacon & Davis advance three

Ford, Bacon & Davis, engineers and constructors with offices in New York, Chicago, Los Angeles, Toronto, and Vancouver, announced the election of three new vice-presidents: L. S. Baldin, in charge of valuation and report work carried on by the company; S. R. Fleming, manager of the Vancouver office; and W. O. Johnson, director of industrial engineering activities.

BRAB advisory studies

The Building Research Advisory Board will undertake six new advisory studies and make recommendations of helpful and practical assistance to the Federal Housing Administration in establishing new technical criteria for consideration in minimum property standards revisions or materials releases, it was announced recently by William H. Scheick, BRAB executive director. Among subjects of the studies of interest to the concrete industry are:

1. Determination of whether or not concrete admixtures are effective as a protection against ground moisture and vapor penetrating slab-on-ground construction, and to develop test procedures needed for determining acceptability for any given admixture.

2. Investigation of conditions under which a moisture barrier is needed for a slab-on-ground above grade level, and conditions under which the barrier may be located on top of a slab; and the moisture protection needed for both slab and walls of habitable spaces below grade.

3. Establishment of criteria for proper design and construction of heated and unheated slabs-on-ground to insure structural soundness, including maximum dimensions of unreinforced slab-on-ground to assure no harmful cracking due to shrinkage and temperature changes, and the amounts of reinforcement necessary for slabs of greater length. Standards of construction for heated and unheated slabs-on-ground that will insure structural soundness in areas of expansive soils will also be developed.

Pretzer appointed chief engineer

Concrete Fabricators, Inc., announces the appointment of C. Andrew Pretzer to the position of chief engineer. Pretzer's headquarters will be in the Cleveland executive offices. Before joining Concrete Fabricators, Mr. Pretzer was assistant head of structural design for Cleveland consulting engineers, McGeorge, Hargett and Associates.

Technical Committees

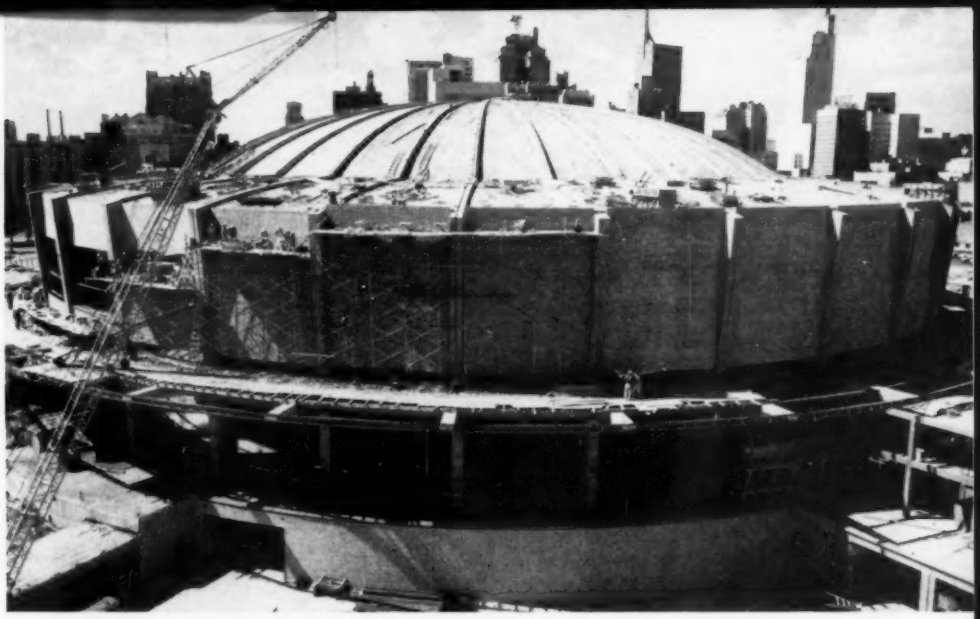
Continued from p. 3

which will serve as a supplement to "Building Code Requirements for Reinforced Concrete (ACI 318-56)." In addition to subjects covered in the original report, new recommendations may cover plain concrete walls, underground structures, and thin precast elements. More complete provisions are anticipated for allowable loads on unreinforced piers, and for temperature and shrinkage reinforcement in thick slabs, thick walls, and slabs on ground.

Mortar applied by pneumatic pressure

Reactivated Committee 805 will review the existing standard "Recommended Practice for the Application of Mortar by Pneumatic Pressure (ACI 805-51)," and will prepare a revision reflecting developments in this field since 1951. Scope of the committee work will be extended to include limits of applicability and recommendations for the use of plastic mix shotcrete, for other admixtures suitable in shotcrete, and for lightweight aggregate shotcrete.

Use of cements other than portland, construction of thick structural members, and special recommendations for joint requirements in thick members and limitations on such thickness will be considered.



Desired Concrete Properties for Dallas Memorial Auditorium obtained with POZZOLITH®

Architect-Engineer: George L. Dahl, Dallas
Consulting Engineer: Ammann & Whitney, New York City
Gen. Contr.: R. P. Farnsworth & Co., New Orleans — Dallas

POZZOLITH was employed to obtain improved control during year-round concreting operations:

- **standard POZZOLITH for average weather work.**
- **a retarding type POZZOLITH for ample placing and finishing time in hot weather.**
- **High Early POZZOLITH to avoid delays in finishing and form removal during low temperatures.**

During all seasons and for all classes of concrete, POZZOLITH provided these benefits with lower water content, resulting in reduced shrinkage, less cracking and great durability.

Architects employed POZZOLITH to meet these requirements most economically. Field service, Dallas Office. (Further details in Master Builders Reporter No. 12 — copy on request.)

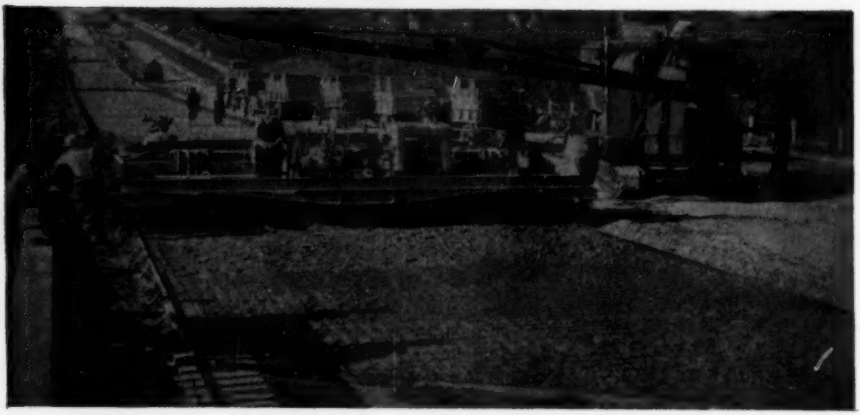
THE MASTER BUILDERS CO.

CLEVELAND 3, OHIO — Division of American-Marietta Company — TORONTO, ONTARIO

it's a concrete fact!

WIRE FABRIC REINFORCING

minimizes slab lengthening



The addition of welded wire fabric to concrete slabs substantially reduces the tendency to lengthen over protracted periods of time. Research on actual highway projects indicates that steel reinforced concrete slabs increase in length only about 1/6 as much due to cracking as non-reinforced concrete slabs over a space of 10 years.*

Minimize your maintenance problems with Clinton Welded Wire Fabric. The cost is paid back many times by extended, trouble-free service life.

*Journal of the American Concrete Institute, June 1954.

***Free* — 16-PAGE BOOKLET**

Get the complete story. Contact our nearest district sales office and ask for Wire Reinforcement Institute publication HT-60, "Reinforced With Welded Wire Fabric." And don't hesitate to tell us about your reinforcing problems. We will be glad to help you select the right reinforcing for your jobs. Of course, Clinton Welded Wire Fabric is made to A.S.T.M. specifications in a variety of gages and spacing.

WHEN THEY ASK...

"is it Reinforced"

SAY YES...WITH

CF&I

CLINTON

WELDED WIRE FABRIC

THE COLORADO FUEL AND IRON CORPORATION—Albuquerque • Amarillo • Billings • Boise • Butte • Denver • El Paso Ft. Worth • Houston • Kansas City • Lincoln (Neb.) • Los Angeles • Oakland • Oklahoma City • Phoenix • Portland • Pueblo Salt Lake City • San Francisco • San Leandro • Seattle • Spokane • Wichita • WICKWIRE SPENCER STEEL DIVISION—Atlanta Boston • Buffalo • Chicago • Detroit • New Orleans • New York • Philadelphia • CF&I OFFICES IN CANADA: Montreal Toronto • CANADIAN REPRESENTATIVES AT: Calgary • Edmonton • Vancouver • Winnipeg

5441

New ASCE officers

The American Society of Civil Engineers has elected Louis R. Howson, Chicago consulting engineer, president for the coming year. New vice-presidents elected for 2-year terms are: Waldo G. Bowman, New York, editor of *Engineering News-Record*, and Samuel B. Morris, Los Angeles consulting engineer and former general manager of the City of Los Angeles department of water and power.

Directors, elected for 3 years are: Weston S. Evans, Orono, Me., head of the civil engineering department at the University of Maine; Craig P. Hazelet of Hazelet and Erdal, Louisville, Ky.; Donald M. Mattern, chief, project planning branch, Tennessee Valley Authority, Knoxville, Tenn.; John E. Rinne, San Francisco, engineer for Standard Oil of California; Philip C. Rutledge, partner in Moran, Proctor, Mueser and Rutledge, New York; and Tilton E. Shelburne, director, Virginia Council of Highway Investigation and Research, Charlottesville.

Both Mr. Bowman and Mr. Shelburne are long-time ACI members.

Tantillo assigned overseas project

John A. Tantillo, construction superintendent for Corbetta Construction Co., Inc., New York, for the past 11 years, has been assigned as project manager of $18 million military seaport and fuel supply base being built at Rota, Spain, under joint contract by Corbetta and Construcciones Civiles, S. A., of Spain. Mr. Tantillo recently was project manager directing the rebuilding of Drydock No. 3 in the Brooklyn Navy Yard.

Frei elected president

Otto Frei, Georgia Lightweight Aggregate Co., Atlanta, was elected president of the Expanded Shale, Clay and Slate Institute at the organization's fifth annual meeting held in September at Atlanta, Ga.

Other newly-elected officers are: first vice-president, W. H. Thomas, McNear Brick Co., San Francisco; second vice-president, Allan P. Taylor, Kenlite, Louisville, Ky.; secretary, L. A. Thorssen, Consolidated Concrete Products, Ltd., Calgary, Alberta; treasurer, Ben F. Park, Buildex, Inc., Ottawa, Kan. All of the officers are ACI members.

Willis T. Moran retires

Willis T. Moran, chief of the chemical engineering laboratory branch of the U. S. Bureau of Reclamation's engineering laboratories at Denver, retired September 30, completing more than 37 years of government service. He had worked continuously in the bureau's engineering laboratories since 1931.

Mr. Moran, recognized authority on cement chemistry, has made many contributions to basic research on portland cement and in the investigations of pozzolanic materials as admixtures to concrete. Under his direction, Bureau of Reclamation laboratories developed new techniques and improvements for reclamation projects, including aromatic solvents for control of aquatic weeds, buried asphalt membrane linings for seepage control in canals, and paint and surface coatings for irrigation structures.

Mr. Moran is a member of ACI, American Chemical Society, and American Society for Testing Materials. He has served on several major committees in these societies; formerly chairman of ACI Committee 212, Admixtures, he is now a member of that group.

Pfeiffenberger made technical director

Lucas E. Pfeiffenberger, ceramic engineer of Urbana, Ill., recently assumed the duties of his new position as technical director of the Expanded Clay and Shale Association, Allentown, Pa. The organization has authorized an intensive test and research program for the development of additional information about the properties of expanded clay and shale lightweight aggregates.

Mr. Pfeiffenberger, formerly associated with the Alton Brick Co., Alton, Ill., has been doing research work at the University of Illinois for the past year. He joined ACI in 1951.

United Concrete Pipe appoints Reeves

United Concrete Pipe Corp., Baldwin Park, Calif., has announced the appointment of George A. Reeves as manager of the prestressed concrete division of the organization. Reeves was formerly general sales manager for Graham Brothers, Inc., of Los Angeles.

ACI Journal gift order form

Help your friends to keep abreast
of latest developments
Give a gift subscription this year
of the ACI JOURNAL

The JOURNAL is recognized as the foremost source of technical information in the United States and throughout the world. For 54 years, ACI has brought the latest developments and techniques to the readers of the JOURNAL. Institute standards and building codes represent accepted methods in concrete construction. Each month, eminent authorities in their field submit the results of their research and production methods to the ACI JOURNAL for publication. It is this exchange of ideas and facts through the pages of the JOURNAL that maintains the modern up-to-date information that provides the newest concepts in concrete construction. Every engineer, architect, manufacturer, production supervisor, contractor, and construction supervisor, wants to keep abreast of the latest methods of design and construction in concrete. This information is available to him only through the pages of the ACI JOURNAL. Right now is the time to order your gift subscription of the ACI JOURNAL. Fill in the coupon; we'll do the rest.

One-year subscription—$12.00

Please send a year of the ACI JOURNAL as my gift—

To_____
(Please Print)

Street & No._____

City_____ Zone_____ State_____

*Sign Gift Card "From*_____

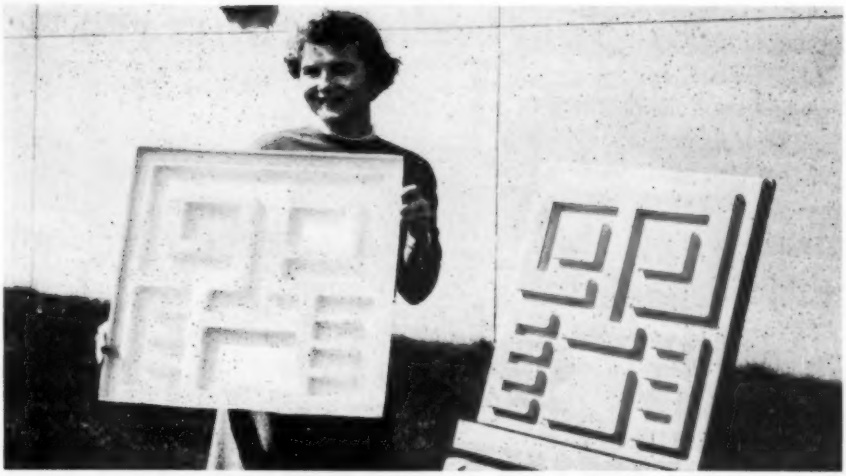
☐ *I enclose $*_____ *or* ☐ *bill me after Christmas*

MY NAME_____

Street & No._____

City_____ Zone_____ State_____

AMERICAN CONCRETE INSTITUTE
P. O. Box 4754, Redford Station, Detroit 19, Michigan



Concrete panels show the type of decorative patterns that can be made with plastic form liners. The liners can be made to order in almost any pattern, are economical and can be reused many times. Liner used in casting the panel detail is exhibited

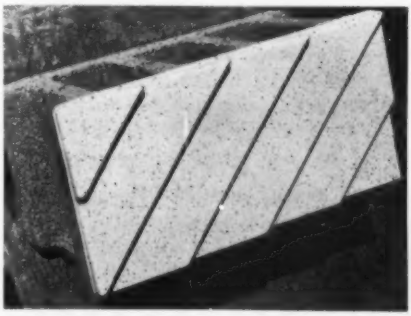
FORM LINERS

Limitless variety of new textures and patterns for concrete surfaces has been made possible by development of plastic and rubber form liners. A recent publication from the Portland Cement Association, Chicago, says the liners produce sharp, crisp patterns and a smooth, almost glassy surface that requires no clean down, grinding, or finishing.

The liners are satisfactory for facing concrete block, producing either a pattern for variety in wall surfaces or a smooth, glossy surface much like glazed block.

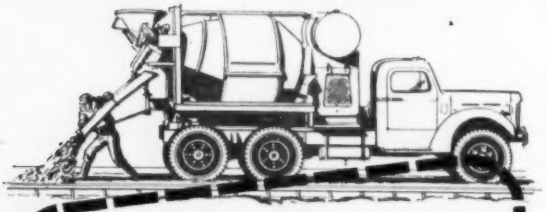
Almost any pattern can be made to order in plastic liners; some textures in rubber liners are already available in stock. Best results are obtained when the patterns are no deeper than ½ in. and edges and corners are rounded.

Both plastic and rubber form liners are relatively low in cost, are reusable many times if handled carefully, need no form oil or bond breaker, and cut finishing costs drastically. No special concrete mix is necessary to achieve good results, and both lightweight and heavyweight aggregates are suitable Both textured and patterned liners can be used successfully for horizontal precast panels, but only the textured liners have so far been used in vertical cast-in-place construction.



Patterned surfaces like this can be used to achieve striking variety in walls, or a smooth surfaced block can be made. Both plastic and rubber form liners produce an easily cleaned concrete facing for block

No time lost when concrete is



SPECIAL WINTERIZED

with SOLVAY CALCIUM CHLORIDE

You save four ways when you order ready-mix that is "special winterized," including a low-cost 2% of SOLVAY Calcium Chloride:

1. You save overtime finishing, because it sets faster.
2. You save delays in form removal, because it develops high early strength.
3. You save delays between operations.
4. You can save up to 50% on protection time.

The concrete is *better* too . . . greater ultimate strength, denser, more moisture-and-wear-resistant.

Solvay Calcium Chloride speeds but does not change the normal chemical action of portland cement. Impartial tests by the National Bureau of Standards prove its advantages in cold weather concrete construction. Adding calcium chloride is recommended or approved by leading authorities, including American Concrete Institute and Portland Cement Association.

Write now for full data!

SOLVAY PROCESS DIVISION

ALLIED CHEMICAL & DYE CORPORATION

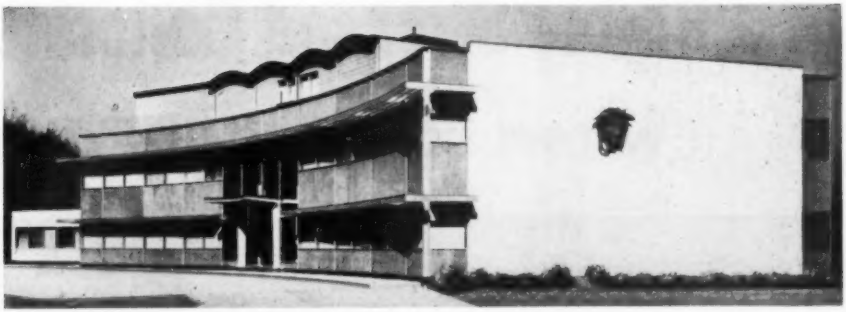
61 Broadway, New York 6, N. Y.

BRANCH SALES OFFICES

Boston - Charlotte - Chicago - Cincinnati - Cleveland - Detroit - Houston
New Orleans - New York Philadelphia - Pittsburgh - St. Louis - Syracuse

Allied Chemical

SOLVAY ®



Designed to demonstrate architectural uses of concrete masonry products, precast and cast-in-place concrete, as well as auxiliary uses of concrete, the new headquarters of Medusa Portland Cement Co. in Cleveland Heights is a pace setter in concrete

Concrete Pace Setter

Multiple uses of concrete

From the placing of the footings, to the thin shell canopy penthouse roof, concrete played an important part in the construction of Medusa Portland Cement's headquarters in Cleveland Heights, Ohio. Structural components of the one-story part of the building (barely visible at far left in photograph) are monolithic concrete basement walls and a reinforced concrete first floor of pan and beam construction. Wide, shallow beams increased head room and reduced excavation costs. The roof of this portion of the building is constructed of bar joists with cast-in-place gypsum concrete deck.

Lift-slab construction

Lift-slab method was used for the floor and roof of the main part of the office building. These slabs, actually flat plates, are 10 in. thick supported on 8 x 8 in. steel box columns made of continuously welded steel angles filled with concrete to prevent condensation and the resulting oxidation. This method of construction made the curve of the building and the sweep of the balcony possible without noticeable influence on cost according to architect Ernest Payer of Cleveland.

The irregular column spacing in the main part of the building presented a design problem from the standpoint of interruptions in the continuity of the slabs. The flat plate was the only feasible solution, particularly since stresses must change direction, and the architectural requirements of the building would not allow for large concrete beams. Column spacing in the two-story lobby presented additional problems with the huge cantilevers that existed before the cast-in-place strips were completed, and additional problems with the resulting long spans of the roof slabs once the cast-in-place strips were in. To accommodate roof loading and the penthouse weight, it was necessary to up-set beams in the roof slab to reduce deflections. These up-set beams served as curbs separating the penthouse from the roof area.

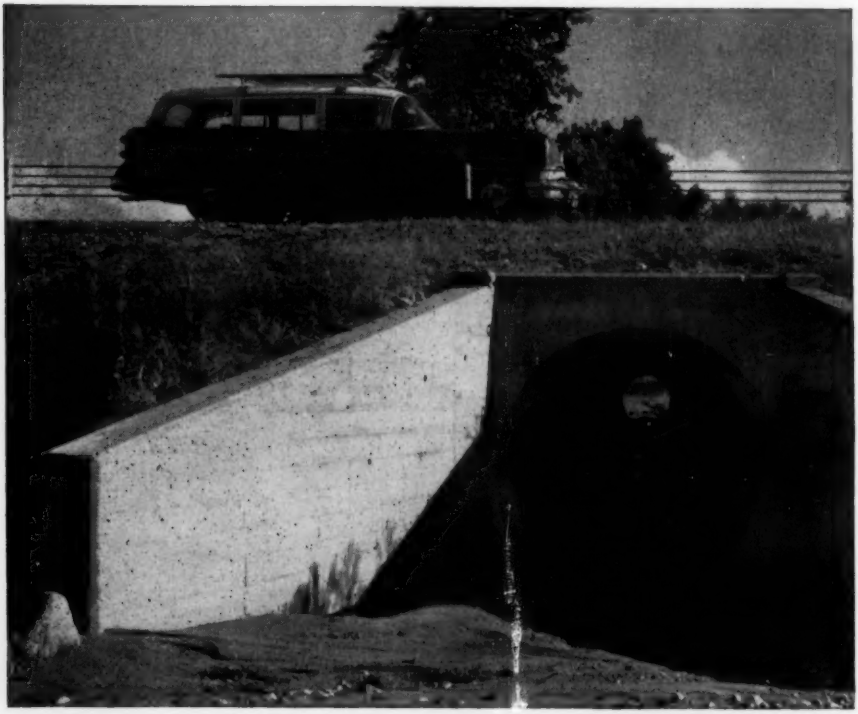
Detail at stairwell

The east end of the main building required a large stairwell which provided a narrow strip of slab with a single column supporting it at its center. The possibility of the slab twisting during lifting and warping the lift-slab had to be considered. To prevent this, some long diagonal reinforcing bars were added to resist the tension stresses that would be developed by warping of the slab, and in addition, a large structural steel channel was

Continued on p. 80

Highly Stressed Concrete

when reinforced with

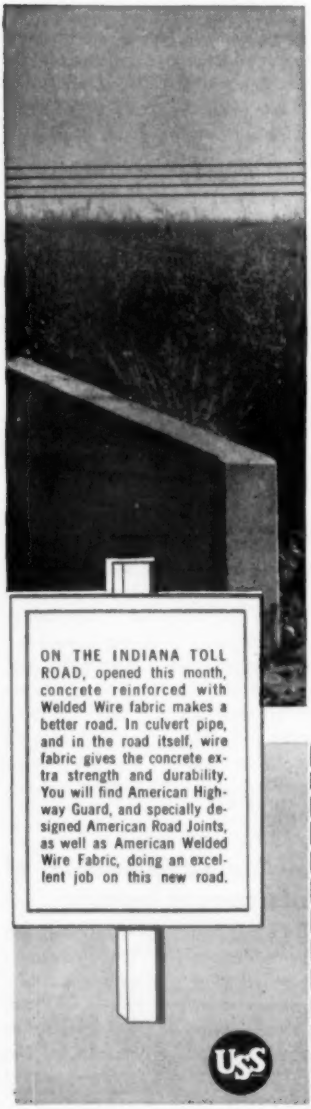


IT PAYS TO ASK *"is it Reinforced"*

USS American Welded Wire Fabric

UNITED STATES STEEL

Lasts Longer
American Welded Wire Fabric


ON THE INDIANA TOLL ROAD, opened this month, concrete reinforced with Welded Wire fabric makes a better road. In culvert pipe, and in the road itself, wire fabric gives the concrete extra strength and durability. You will find American Highway Guard, and specially designed American Road Joints, as well as American Welded Wire Fabric, doing an excellent job on this new road.
USS

Concrete roads, floor slabs, pipe, walls, sidewalks—all are improved with Welded Wire Fabric reinforcement. They have greater resistance to cracking, last longer, and stay smoother. And now, for concrete that must withstand unusually high stresses, American Welded Wire Fabric comes in larger sizes than formerly. It's now available in diameters up to and including ½", at 2", 3", 4", and 6" on center. It meets ASTM Specification A 185 56T.

The high quality of American Welded Wire Fabric is rigidly controlled from iron mine to you. Made from tough, cold-drawn steel . . . then electrically welded together into a strong network of durable reinforcement, it cuts maintenance cost because it increases service life of concrete. It cuts *installation* costs because it is easily handled and placed. It comes in both sheets and rolls. Send the coupon for helpful literature on this and other construction materials manufactured by American Steel & Wire.

AMERICAN STEEL & WIRE
DIVISION
UNITED STATES STEEL, GENERAL OFFICES: CLEVELAND, OHIO

COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA., SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

FREE TECHNICAL DATA

American Steel and Wire
Dept. 6D-117, Rockefeller Bldg.
Cleveland 13, Ohio

Please send complete information on the following products:

- ☐ American Welded Wire Fabric for Portland Cement Concrete
- ☐ American Welded Wire Fabric for Asphaltic Concrete
- ☐ American Welded Wire Fabric for Airport Runways
- ☐ American Wire and Strand for Prestressed Concrete
- ☐ American Road Joints
- ☐ Multisafty Highway Cable Guard
- ☐ American Beam-type Highway Guard
- ☐ Have your representative call

Name .....

Firm .....

Address .....

City ..... **State**.....

Continued from p. 17

cast into the concrete at the edge of this opening to act as a stabilizer and thus prevent the slab from twisting.

Shell roof

The penthouse roof of thin shell concrete is made up of four multiple span barrel shells, 3½ in. thick with chord lengths 12 ft 3 in. to 15 ft 6 in. and spanning 29 ft to 37 ft parallel to the axis of the shells. Shell axes are tipped so that their tops are higher at one end, at the same time diverging to match the radial lines of the curved building. This shape of the shells required careful framework and placing of reinforcing steel according to structural engineer Richard Gensert, of Gensert, Williams and Associates, Cleveland.

Precast wall panels

Thin curtain wall concrete panels were used on the exterior walls of the main section of the building. The east and west exterior walls are made of solid white concrete panels with white marble chips as an exposed aggregate finish. The north and south walls are formed by precast insulated panels with exposed colored aggregate. The curtain wall panels are hung from the slabs by heavy steel angle connections which carry the vertical load. Panels are stabilized against wind by their final connection to aluminum horizontal and vertical mullions that complete the exterior wall construction.

On the east wall of the building, visible to the passerby, is a 5 ft high head of Medusa cast in white concrete. This originally neoclassical trademark was redesigned by William McVey in harmony with the structure's contemporary style.

The west wall of the lobby is made of special precast concrete panels designed by sculptor William McVey to present a raindrop effect in light and shadow. The east wall is of polished silver-gray, artificial granite, to further demonstrate the unlimited types of finishes that can be achieved with concrete. The riserless stairway in the lobby is made of precast, reinforced terrazzo treads united by a central stringer of cast-in-place concrete.

Brown Construction Co., Cleveland, was general contractor. Precast panels were produced by the Marietta Concrete Corp., Marietta, Ohio.

Roll moves to Pennsylvania

Frederick Roll, formerly with the department of civil engineering and engineering mechanics, Columbia University, has joined the staff of the University of Pennsylvania.

In his new position as associate professor in the university's school of civil engineering, he will be in charge of the materials and the cement and highway materials laboratories. Dr. Roll has conducted considerable research on creep of concrete under high stresses and the study of diagonal tension in reinforced concrete beams. He is a member of Joint ACI-ASCE Committee 326, Shear and Diagonal Tension, and has been a member of ACI since 1955.

Canadian products group schedules convention

The ninth annual convention of the National Concrete Products Association of Canada will be held Feb. 24-26, 1958, at the Seigniory Club, Montebello, Quebec. About 300 delegates representing all branches of the concrete products industry and suppliers from Canada and the United States are expected to attend.

Theissing studies concrete

E. M. Theissing, research manager, Bredero's Bouwebedruf N.V., representing ACI member J. De Vries, Utrecht, Netherlands, is touring the United States on a personal survey of concrete research. He visited ACI headquarters and a lightweight aggregate plant in Detroit last month. Mr. Theissing is especially interested in exchanging data on heavy concrete, refractory concrete, mass concrete thermal design, and synthetic lightweight aggregate.

Stoughton named president of Wire Reinforcement Institute

Wayne O. Stoughton, steel executive, has been named president of the Wire Reinforcement Institute for the coming year. Mr. Stoughton, who is manager of sales of Pittsburgh Steel Co., became an ACI member in 1956. Earl C. Planett, president of the Planett Mfg. Co., Downey, Calif., was named vice-president.

QUALITY and ECONOMY in COLD WEATHER CONCRETE FLOOR CONSTRUCTION

You can economically place high quality concrete floors in cold weather by using Sikacrete Accelerating Densifier.

EARLY STRENGTH – Sikacrete is a liquid admixture which causes rapid strength development in concrete and mortar. Sikacrete saves hours of overtime finishing and reduces the possibility of damage by freezing. Floors may be opened to traffic sooner.

STRUCTURAL BENEFITS – Sikacrete contains Plastiment densifying agent which gives these structural benefits: greater density, hard non-dusting surfaces, increased ultimate strength, and reduced cracking.

PLACEABILITY – The easy placeability of a stiff Sikacrete mix will surprise the most experienced concrete men. Sikacrete concrete with a 3" slump will be as easy to place as plain concrete with 5" slump. The excellent troweling characteristics will enable the finisher to provide a superior finish.

PROPORTIONS – Sikacrete proportions may be varied to suit job conditions. Normally 1½ gallons are used per cubic yard.

ECONOMY – In addition to lower finishing costs, early strength reduces both the time and cost of cold weather protection. You will increase structural quality and pocket savings greater than the cost of Sikacrete.

OTHER USES – Sikacrete is also a money-saver when laying brick or masonry units, and when placing structural concrete in cold weather. Advantages include faster job progress, improved quality, and the reduction or elimination of white deposits of efflorescence.

Let Sikacrete increase production, quality, and profit in your winter concrete and masonry work. Write or call today for complete information.

Sikacrete Accelerates Set for Early Floor Finishing

SIKACRETE® ACCELERATING DENSIFIER

SIKA CHEMICAL CORPORATION

Passaic, New Jersey

DISTRICT OFFICES: BOSTON • CHICAGO • DALLAS • DETROIT
PHILADELPHIA • PITTSBURGH • SALT LAKE CITY • WASHINGTON, D.C.
DEALERS IN PRINCIPAL CITIES—AFFILIATES AROUND THE WORLD

SIKA CHEMICAL CORPORATION
35 GREGORY AVE. • PASSAIC, NEW JERSEY

Please send information on Sikacrete

NAME_____

COMPANY_____

ADDRESS_____

Integrated concrete beams and columns support tons of piping!

Pipe supports for chemical plant. Photo shows method of beam tie-in.

Concrete beam tie-in simplified . . . round concrete columns erected with

Sonoco SONOTUBE® Fibre Forms

Pipe supports for a chemical plant consist of an integrated reinforced concrete beam and column structure.

Sonoco SONOTUBE Fibre Forms were used to erect the round concrete columns. Prior to pouring, openings cut into the fibre forms were blocked with wood carrying reinforcing steel "dowels" through the diameter of the form.

After the pour and necessary curing time, the forms were stripped and the steel dowels were welded to the reinforcing steel of the concrete beams. A simple box form was then used to grout the beam tie-in.

Versatile, low-cost Sonoco SONOTUBE Fibre Forms save time, money and labor in the construction of underpinning, piers, piles and supporting columns.

See our catalog in Sweets

In sizes from 2" to 48" I.D., up to 48' long. Order in specified lengths or saw to requirements on the job.

For full information and prices, write

SONOCO PRODUCTS COMPANY

CONSTRUCTION PRODUCTS DIVISION

HARTSVILLE, S. C.

LOS ANGELES, CAL. 5955 SOUTH WESTERN AVE.

MONTCLAIR, N. J. 14 SOUTH PARK STREET

AKRON, IND. • LONGVIEW, TEXAS • BRANTFORD, ONT. • MEXICO, D. F.

2752

Who's Who This Month

E. G. Swenson

"Winter Concreting Trends in Europe" appearing on p. 369 was prepared by E. G. Swenson, research officer in charge of cement and concrete research, Division of Building Research, National Research Council (Canada), Ottawa.

Mr. Swenson received his master's degree from the University of Saskatchewan where he did graduate and post-graduate research in cement chemistry. Prior to assuming his present position he served as assistant professor in chemistry at the University of Saskatchewan.

This paper represents his second contribution to the ACI JOURNAL. He was co-author with V. Chaly, also of the National Research Council, of an article entitled "Basis for Classifying Deleterious Characteristics of Concrete Aggregate Materials," which appeared in May, 1956.

J. C. Saemann and G. W. Washa

J. C. Saemann and G. W. Washa have collaborated on a paper entitled "Variation of Mortar and Concrete Properties with Temperature," on p. 385 of this month's JOURNAL.

J. C. Saemann, received his BS degree in civil engineering and a PhD in engineering mechanics at the University of Wisconsin. Now an assistant professor of mechanics at the University of Wisconsin, he joined the staff in 1946 upon leaving the U. S. Navy.

G. W. Washa is professor and chairman of the department of mechanics at the University of Wisconsin, where he graduated in 1938. An active ACI member since 1940, Professor Washa has been a frequent contributor to the JOURNAL. In 1940 he was awarded the Wason Medal for Research for work reported in his paper "Comparison of the Physical and Mechanical Properties of Hand Rodded and Vibrated Concrete Made with Different Cements."

Professor Washa is chairman of ACI Committee 115, Research, and a member and former chairman of Committee 213, Properties of Lightweight Aggregates and Lightweight Aggregate Concrete; Committee 609, Compaction of Concrete by Mechanical Means; and Committee 613, Recommended Practice for Proportioning Concrete Mixes.

K. E. McKee and E. I. Fiesenheiser

"A Critical Look at Slab Design Methods" on p. 397 has been prepared by the co-authors, K. E. McKee and E. I. Fiesenheiser.

K. E. McKee, research engineer in the structural analysis section at Armour Research Foundation of Illinois Institute of Technology, Chicago, received BS and MS degrees in civil engineering from Illinois Institute of Technology. Prior to joining the foundation staff in 1954, Mr. McKee worked on the structural design of reinforced concrete buildings for Swift and Co., Chicago.

At Armour Research Foundation he has done considerable research on ultimate strength of structures, structural dynamics, and weapons effect, in connection with the analysis and design of structures subjected to blast loading either from a nuclear or high explosive detonation. He is a member of the ASCE committee on reinforced masonry design and practice, and has been an ACI member since 1955.

E. I. Fiesenheiser is professor and director, civil engineering department, Illinois Institute of Technology, where he began his teaching career as an instructor in 1943. He has done structural engineering work for the American Bridge Co., U. S. Bureau of Public Roads, Chicago Sanitary District, and Arthur G. McKee and Co.

Active as a structural consultant, Professor Fiesenheiser has spent considerable time on design and analysis of tall steel towers; he designed heavy concrete shielding for the University of Chicago's large cyclotron and has directed research in the development of heavy concrete for radiation shielding (his paper on this appeared in the September 1955 JOURNAL) and the design of multistory building for low-rent housing and related research projects carried out at the Illinois Institute of Technology.

Professor Fiesenheiser wrote "Rapid Design of Continuous Prestressed Members," which appeared in the April 1954 JOURNAL, and is co-author of a manual for U. S. Army officers, TM 5-260, *Principles of Bridging*.

He has been an ACI member since 1946 and is a member of ACI Committee 318, Standard Building Code.

William Shelson

William Shelson, chairman of the operations research group, Hydro-Electric Power Commission of Ontario, Toronto, is author of "Bearing Capacity of Concrete" published on p. 405.

In his present position and with former employers, Curtiss-Wright Corp. and Brown University, Dr. Shelson has worked in the general field of applied mechanics. Projects have included stresses in propeller mechanisms, prestressed concrete bridges, and cellular cofferdams; thermal stresses in concrete dams; vibrations in rotating machines; and water hammer in pipe lines.

A graduate of the University of Toronto, he is now engaged in the application of operations research to the solution of business problems. Dr. Shelson's publications include studies on the fatigue strength of aluminum, photoelastic stress analysis, and hydraulic surge-tank performance.

Sam Hassid

"Temperature Stresses in Continuous Frames" published on p. 415 was submitted by Sam Hassid, chief structural engineer, Ammann & Whitney, Paris, France.

Mr. Hassid, an ACI member since 1953, graduated from the Imperial College of Science and Technology in England in 1952. The following year he received his master's degree from the University of Illinois. Specializing in the design of hangars, warehouses, and other special structures, typical projects he has worked on include: the Trans-World Airlines hangar at Kansas City; Pan American Airways hangar, New York; a steel sectional floating drydock for the U. S. Navy; and the Chateauroux hangar in France.

No more algebraic formulas or calculations to make. Simply locate the table covering the member you are designing, apply span and load requirements, and then *read off directly* concrete dimensions and reinforcing steel data. Follows the latest codes and practices. Send check or money order for your copy, today.

Prepared by The Committee on Engineering Practice

CONCRETE REINFORCING STEEL INSTITUTE

38 S. Dearborn St., (Div. J) Chicago 3, Illinois

Honor Roll

February 1—September 30, 1957

The first four places remain the same this month with G. B. Southworth first with 18 credits, Blas Lamberti second with 15, Arthur N. L. Chiu third with 9, and H. C. Pfannkuche fourth with 8 credits.

We hope that membership will reach 9500 by the close of the Honor Roll year. You can help achieve this goal by having your name added to the Honor Roll which will mean that you have proposed two or more new members to the Institute.

G. B. Southworth	18
Blas Lamberti	15
Arthur N. L. Chiu	9
H. C. Pfannkuche	8
Luis Perez Cid	6
Phil M. Ferguson	6
Martin J. Gutzwiller	6
Walter H. Price	6
Jaime de las Casas	5
W. H. Armstrong	4
Nicandro Barboza	4
W. S. Cottingham	4
Ambrosio R. Flores	4
Louis A. Gottheil	4
Myle J. Holley, Jr.	4
J. E. Jellick	4
Franklin B. Johnson	4
Henry L. Kennedy	4
L. M. Legatski	4
James A. McCarthy	4
Frederick T. Mavis	4
Martin Schulz	4
S. E. Acker	3
James C. Amrhein	3
Luther E. Bell	3
Geo. F. Bishop	3
R. F. Blanks	3
William V. Coyle	3
C. A. Engman, Jr.	3
Samuel Hobbs	3
R. A. Kirkpatrick	3
Leo Liberthson	3
Robert H. Lochow	3
Sam C. McClure	3
I. Martin	3
George H. Nelson	3
Wm. C. Schwenger	3
Howard Simpson	3
H. T. Williams	3
John T. Young	3
Roberto Zepeda	3
Miles N. Clair	2½
Carlos D. Bullock	2
Jose L. Capacete	2
James Chinn	2
Dale Cobb	2
Roger D. de Cossio	2
C. F. DeVilbiss	2
George A. Dinsmore	2
Andrew G. Fallat	2

Use

ECONOFLEX

***Flexible* ARMORING**

POST TENSION CASING

Fabricated with fully interlocking four wall construction out of .012" strip, having excellent impact crush resistance.

Write for Bulletin U-100BX2

Quality ... ALL METAL FLEXIBLE HOSE PRODUCTS

UNIVERSAL METAL HOSE CO.

2101 S. Kedzie Ave., Chicago 23, Illinois

E. I. Fiesenheiser	2
Kenneth H. Gedney	2
Albert Haertlein	2
Roger E. Harlepp	2
N. L. Hinkson	2
M. W. Huggins	2
F. R. Khan	2
Yavuz Kirec	2
Oscar Latorre M.	2
Harry McLean	2
Partick McNally	2
A. J. Macchi	2
Ronald A. Maina	2
Izuo Miyashita	2
Otto H. Monch	2
John M. Muir	2
D. F. Nash	2
Richard A. Parmelee	2
Abdur Rahman S. Rasul	2
Theodore O. Reyhner	2
Sabri Sami	2
Wallace Sanders, Jr.	2
Harry Saxe	2
Harold Schweitzer	2
Marcel V. Sous de C.	2
Joaquin Spinel L.	2
J. P. Thompson	2
E. W. Thorson	2
Ellis S. Vieser	2
Joseph J. Waddell	2
D. K. Woodin	2

Errata

The following correction should be made in "Under-Reinforced Concrete Beams Under Long-Term Loads," by Herbert A. Sawyer, Jr., and Jack E. Stephens, in the July 1957 JOURNAL:

p. 26—The first numerical quantity in Eq. (4) should be 0.014 instead of 0.14.

* * * *

The following corrections should be made in "Guide for Ultimate Strength Design of Reinforced Concrete," by Charles S. Whitney and Edward Cohen, in the November 1956 JOURNAL:

p. 468—Substitute the following for Fig. 6:

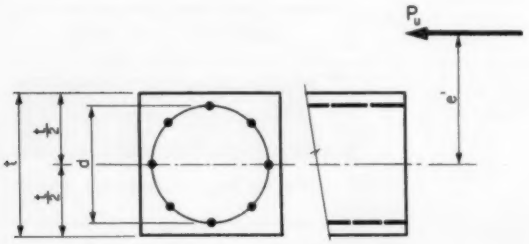


Fig. 6

p. 468—Substitute the following for Fig. 7:

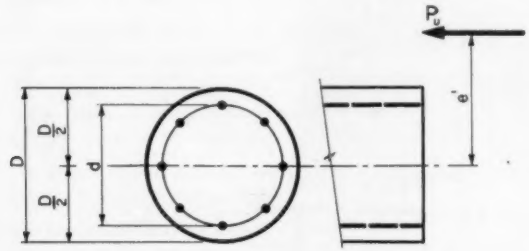
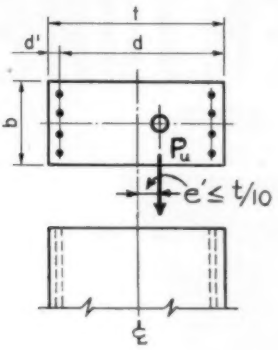


Fig. 7

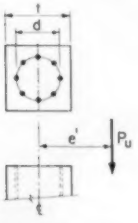
p. 471—Lines 6 and 7 should read "from the formulas for concentrically loaded and eccentrically loaded short columns and combined bending and axial compressive load or from Charts 2-15."

p. 474—Add "psi" at the end of Line 33.

p. 477.—Substitute the following for the corresponding portion of the upper left corner of Chart 2.

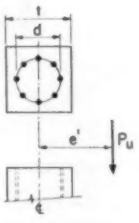


p. 483ff.—Substitute the following for the corresponding parts in the upper right corners of Charts 8-15, inclusive.



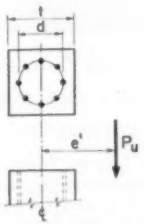
d/t=0.90

Chart 8



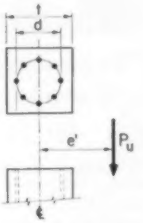
d/t=0.80

Chart 9



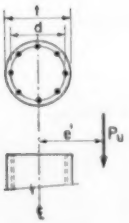
d/t=0.70

Chart 10



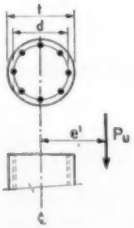
d/t=0.60

Chart 11



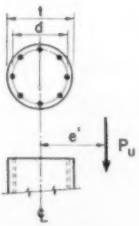
d/D=0.90

Chart 12



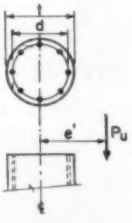
d/D=0.80

Chart 13



d/D=0.70

Chart 14



d/D=0.60

Chart 15

* * * *

Corrections for "Design of Blast Resistant Construction for Atomic Explosions," by C. S. Whitney, B. G. Anderson, and E. Cohen, in the March 1955 ACI JOURNAL, *Proceedings* V. 51, are available on request in leaflet form from ACI Publications Department.

SERVICISED

"CEMENTONE"

SPONGE RUBBER JOINT FILLER

★ Non-Extruding...High Recovery After Compression

★ Weather and Rot Resistant

★ Gray Color Blends With Concrete

"Cementone" is a High Density Material, Especially Designed for the Construction Industry

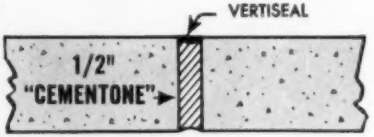
Servicised "Cementone" Sponge Rubber is a maximum performance joint filler, designed for applications where utmost resilience, non-extrusion, high recovery, material stability and resistance to the deteriorating effects of weather, mildew and rot are required. It is also widely used in exposed architectural concrete such as bridges and overpass structures, abutments, walls, etc. where its neutral gray color blends well with the color of concrete.

Because of its compressibility, high resilience and color, "Cementone" is ideally suited for use in tilt-up construction at vertical column and panel butt joints. (below)

Made from high quality blown sponge rubber, uniform in thickness and density, "Cementone" is available in cut strips or sheets in standard thicknesses of ¼", ⅜", ½", ¾" and 1" in lengths up to 10 ft. For greater thicknesses, "Cementone" may be laminated.

Typical "Cementone" Tilt-up Applications

"Cementone" Sponge Rubber used on wall sections with column vertical joint.



Sealing a butt joint of precast wall panels. Vertiseal is used to seal the exterior face.

Write for the Servicised Catalog. There's no obligation.

SERVICISED PRODUCTS CORPORATION

6051 WEST 65th STREET • CHICAGO 38, ILLINOIS

New Members

The Board of Direction approved 73 individual applications, 1 Corporation, 23 Juniors, and 7 Students, making a total of 104 new members. Considering losses due to deaths, resignations, and nonpayment of dues, the total membership on Oct. 1, 1957, was 9032.

Individual

AKOL, HALUK, Berkeley, Calif. (Struct. Engr.)

ALBRECHT, W., Stuttgart-O, Germany (Prof. Dr.-Ing., Abteilungsleiter, Forschungs-und Materialprufungsanstalt fur das Bauwesen)

AMIR-FAZLI, NASSAR, Chicago, Ill. (Struct. Engr., Alfred Benesch & Assocs.)

ARMSTRONG, J. A., Lancaster, N. B., Canada (Mgr., Atlantic Div., Master Builders Co.)

BARNES, A. R., Boston, Mass. (Pres., Barnes & Jarnis, Inc.)

BIANCHINI, ALBERT C., Urbana, Ill. (Instr. of Theoretical & Applied Mechanics, Univ. of Ill.)

BOOTH, ROBERT V., Painesville, Ohio (Pres. & Gen. Mgr., The Union Sand & Supply Corp.)

BREMER, RAYMOND V., Denver, Colo. (Struct. Engr., Stearns-Roger Mfg. Co.)

CIURLIONIS, BALYS, Canoga Park, Calif. (Sr. Engr. in Struct. Design, Rocketdyne, Div., of North American Aviation Inc.)

CLAYWORTH, CARL J., Louisville, Ky. (Distr. Mgr., Pittsburgh Testing Lab.)

CRAIG, CURTIS L., Omaha, Neb. (Struct. Engr., Corps of Engrs., U. S. Army)

CROWELL, HAROLD M., Baghdad, Iraq (Constr. Engr., Supv., Tippetts, Abbett, McCarthy, Stratton, Engrs.)

CURIANO, ARISTON M., Agana, Guam (C. E., Area Pub. Wks. Center)

DOUGLAS, WALTER J., West Hartford, Conn. (Cons. Engr.)

DRHA, ALFRED, Hamilton, Ont., Canada (Sr. Draftsman-Designer, Steel Company of Canada, Ltd.)

DUQUE VILLAREAL, TOMAS GERARDO, Panama, Rep. de Panama (Cons., Specialize in Structures, Contr.)

FERRIS, WALTER R., Cambridge, Mass. (Lecturer in C. E., Harvard Univ.)

FRAENKEL, H. ROLAND, Wellington, New Zealand (Arch. & Struct. Engr., specializing in concrete work)

GALINATO, JUAN G., Quezon City, Philippines (C. E., Engrg. & Development Corp. of the Philippines)

GARGASAS, ANTAMAS, Cleveland, Ohio (Struct. Engr., Inspection)

GAYNOR, MONTAGUE, London, England (Concrete Engr., Sir Bruce White, Wolfe, Barry & Partners)

GHINE, OHN, M. B. Los Angeles, Calif. (Asst. Engr., National Housing Board)

GIOMETTI, AUGUST SAMUEL, Atlanta, Ga. (Prof. Engr., Associated Consultant Engrs.)

GOLSON, CHARLES E., San Francisco, Calif. (Dev. Mgr., Aggregate Benefication Dept., Western Machinery Co.)

GORING, JOHN HENRY, Vancouver, B. C., Canada (Concrete Steel Inspector, Coast Testing & Inspecting Engrs.)

GRAVES, H. B. R., Vancouver, B. C., Canada (Prod. Mgr., B. C. Concrete Ltd.)

HARRISON, WALTER N., New York, N. Y. (Matls. Engr., U. S. Corps of Engrs., Mediterranean Div.)

HEAD, EDWARD J., Cohoes, N. Y. (Vice-Pres. in chge of Sales Promotion, Advertising and Distribution of Product, Northern Lightweight Aggregate, Inc.)

HERBACSEK, MICHAEL, New York, N. Y. (Engr., Sigmund Roos)

HIBLING-KEILLER, T., Ottawa, Ont., Canada (Struct. Engr., Dept. National Defence, Gov't. of Canada)

HIED, ROBERT E., Beloit, Wis. (Technical Service Engr., Medusa Portland Cement Co.)

HILDEBRANDT, ROSCOE C., Seattle, Wash. (Distr. Struct. Engr., PCA)

HOEFFEL, DONALD E., Cincinnati, Ohio (Struct. Engr., PCA)

IRAGORRI, JAIME, Ft. Lauderdale, Fla. (C. E., R. H. Wright & Son)

JACKSON, GEORGE ERNEST PETER, Leeds 9 Yorks, England (Works Mgr., Trumix Concrete)

JOHNSON, WALTER H., Mercury, Nevada (Field Engr., Constr. Insp., etc., Holmes & Narver, Inc.)

KING, LOYD H., JR., Levittown, Pa. (Sales, Industrial Sales Div., Phila. Office., The Master Builders Co.)

LEE, HAROLD M., Rapid City, S. Dak. (Res. Engr. Asst., S. Dak. Dept. of Hwys., Geo. P. Ducey, Res. Engr.)

LEMONS, VANBUREN H., Sacramento, Calif. (Assoc. C. E., Design Engr., Dept. of Water Resources, Div. of Design & Constr.)

LITTLE, R. M., Sydney, NSW, Australia (Partner, Morrison & Little, Cons. Struct. Engrs.)

LUNDQUIST, J. ROBERT, York, Pa. (Tech. Service Engr., Medusa Portland Cement Co.)

LUSICH, GEORGE JERRY, Bakersfield, Calif. (Asst. Proj. Engr., County of Kern)

MALCHOW, H. C., Gulfport, Miss. (Cons. Engrg., Structural)

MCALISTER, WILLIAM A., San Francisco, Calif. (Mgr., Far East Div., Adrian Wilson & Assocs., Archs. & Engrs.)

MATSON, LAWRENCE E., Idaho Falls, Idaho (Arch. Engr., Norman J. Hamill & Assocs.)

MONTES, HUMBERTO VIANA, Barranquilla, Colombia (Assoc. Member, "Arcos Ltda.")

NILSON, ARTHUR H., Ithaca, N. Y. (Asst. Prof., C. E. Struct., Cornell Univ.)

OCASIO-CABANAS, JUAN R., Caparra Heights, P. R. (Supv. C. E., U. S. Naval Sta. Roosevelt Rds.)

OLSEN, BRUCE C., Seattle, Wash. (Cons. Engr.)

OLSEN, K., Pointe Claire, Que., Canada (Director & Supv. Engr., Atlas Constr. Co., Ltd.)

OSENBURG, RICHARD, San Francisco, Calif. (C. E., U. S. Navy, Barbers Pt., Oahu, T. H.)

PERRINO, SAM, New Castle, Pa. (Jr. Tech. Service Engr., Medusa Portland Cement Co.)

REISS, ERWIN, St. Petersburg, Fla. (Struct. Engr.)

REVILLA, JOSE, Guatemala, Guatemala (C. E., Municipalidad de Guatemala)

RUSSELL, THOMAS O., JR., Fullerton, Calif. (Concrete Field Engr., Super Concrete Emulsions, Ltd.)

SANDSTEDT, CARL EDWARD, College Station, Tex. (Prof. A & M College of Texas)

SCHLESINGER CARRERA, L., Guatemala, Guatemala (Cons. Engr., Contr.)

SCHMIDT, JOHN M., Regina, Sask., Canada (Struct. Design, Industrial Engrg., Joseph Pettick, Arch.)

SCOTT, JOHN A., Fanwood, N. J. (Struct. Designer, Porter, Urquhart, McCreary & O'Brien)

SEIDEL, S., Berlin Grunewald (West), Germany (Diplomatic Engr., Dir. of C. E., Dept., Allegeine Electricitaetsge-Sellschaft (AEG)

SHATTO, HARRY H., Hayward, Calif. (Cons. C. E.)

SHIMEBUKURO, ROY S., Honolulu, T. H. (Struct. Engr., Distr. of Pub. Wks. Design Div., 14th Naval Distr.)

SPODEN, HAROLD T., Kingsport, Tenn. (Cons. Engr., Struct. & Hwy Design)

STEVES, BERT F., Kansas City, Mo. (Chf. Proj. Engr., Black & Veatch, Cons. Engrs.)

SZYMANSKI, STAN JOSEPH, Floral Park, L. I., N. Y. (Lead Struct. Engr., Burns & Roe, Inc.)

TALMAN, ROBERT, Lincolnwood, Ill. (Struct. Engr., Quaker Oats Co.)

THOMPSON, CLARENCE RHODES, Jamaica, N. Y. (Struct. Designer, F. H. McGraw, Engrg. Constrs.)

TREETER, WERNER H., Edmonton, Alta., Canada (Retailing, Bending & Placing of Reinforcing Steel, Treeter Concrete Reinforcing)

TYSON, CHRISTOPHER G., Coral Gables, Fla. (Design Engr., Maurice H. Connell & Assocs.)

VEGA, FERNANDO, Caracas, Venezuela (Bookseller, Libreria Tecnica Vega)

WARDLE, D. JAMES, Montreal, Que., Canada (Sr. C. E., Racey, MacCallum & Assocs.)

WOLF, HERBERT C., St. Louis, Mo. (C. E., Sanitary & Struct.)

WOLFERT, PAUL J., Mattoon, Ill. (Gen. Sales Mgr., Constr. Equip, Div., Blaw-Knox Co.)

Junior

AHMED, MARGHOOB, Minneapolis, Minn. (Struct. Engr., U. S. Corps of Engrs.)

BEAM DATA
Depth, 21''; Width, 36''; Span Length, 40' 4''
Designed for H20-S 16-44 highway load
Manufactured by
MISSOURI PRES-CRETE, INC.
Overland, Missouri

LACLEDE REINFORCING STEELS strengthen PRESTRESSED concrete

Laclede quality welded wire fabric is shown being placed as the outer reinforcement in the forms, prior to the pouring of prestressed concrete girders at Missouri Pres-Crete, Inc. in Overland, Mo.

Girders, joists and columns manufactured here for highway bridge construction, roof and floor supports, permit faster erection in the field at lower cost—while offering greater architectural flexibility and lower subsequent maintenance cost for wide span, heavy load structures.

Laclede Reinforcing Steels for prestressed and precast concrete members:

multi-rib deformed reinforcing bars — *welded wire fabric*
prefabricated joist reinforcement — *high strength wire*

LACLEDE

LACLEDE STEEL COMPANY

SAINT LOUIS, MISSOURI

Producers of Steel for Industry and Construction

BISAILLON, ANDRE, St. Lambert, Montreal, Canada (Jr. Engr., Concrete., The St. Lawrence Seaway Authority)
BRAVO, JOSE M., Medellin, Colombia (Ingeniero Jefe Departmento Tecnico, Carretera Medellin Taraza)
BRODIE, ANDREW F., Toronto, Ont., Canada (Jr. Engrg. in Trng., Ontario Hydro)
CATANI, MARIO J., Ridgefield Park, N. J. (Struct. Designer, Hwy Bridges, Boswell Engrg. Co.)
CROWLEY, PHILIP L., North Canton, Ohio (Design Engr., Macomber, Inc.)
DEUTSCH, PETER L., Bethlehem, Pa. (Research Asst. in Struct. Concrete Div., Fritz Lab., Lehigh Univ.)
DOWNES, EARL F., Moravia, N. Y. (Bldg. Tech., Ward Bancooft)
FROST, J. E., Wellington, New Zealand (C. E., Struct. Design, Ministry of Works, Wellington Distr. Office)
HERNANDEZ, NICHOLAS M., Chicago, Ill. (Sr. Design Engr., Harza Engrg. Co.)
HUNTER, DAVID A., JR., New Orleans, La. (Engr., Struct. & Civil Design, B. M. Dornblatt & Assoc.)
HOWE, CALVIN B., Ft. Lauderdale, Fla. (Gen. Mgr., Detailing & Est., Floridian Crane & Steel Erection)
KING, RANDOLPH S., JR., College Sta., Tex. (Grad. Asst., Texas Transportation Inst.)
MCGRATH, SYDNEY L., New York, N. Y. (Struct. Designer, Supv., Boswell Engrg. Co.)
MONTEMAYOR, JOSE LUIS, Bethelehem, Pa. (Research Asst., Fritz Engrg. Lab., Lehigh Univ.)
NOEL, JAMES S., College Sta., Tex. (Research Asst., Texas Transportation Inst.)
QUEHL, ALFREDO HIDALGO, San Salvador, El Salvador (C.E.)
SABA, BAHIJ K., Boston, Mass. (Sr. Draftsman, Jackson & Moreland, Inc.)
SCOTT, NORMAN L., Ft. Lauderdale, Fla. (Sales Engr., R. H. Wright & Son)
SEE, WILLIAM JAMES, Berkeley, Calif. (Asst. Bridge Engr., State of Calif., Dept. of Pub. Wks., San Francisco Bay Toll Crossings)
TANDOWSKY, SANFORD, Millbrae, Calif. (Struct. Designer, Hall, Pregnoff & Matheu, Struct. Engrs.)
WHEELER, RALPH NORMAN, JR., Hopedale, Mass. (Struct. Engr., Corps of Engrs., N.E.D.)
WONG, SIU-LEUNG, Hong Kong, China (Asst. Struct. Engr., Wong Cho-Tong)

Student

FARNSWORTH, HUGH, III, Blacksburg, Va. (Va. Polytechnic Inst.)
FELDMAN, RICARDO WILKOWSKI, Habana, Cuba (School of Engr., Univ. of Havana)
HOADLEY, PETER GEORGE, Urbana, Ill. (Univ. of Ill. (Research Asst.)
HOM, JOHN HOLMES, Berkeley, Calif. (Univ. of Calif.)
MONAGIN, ROBERT DEAN, Detroit, Mich. (Wayne State Univ.)
RISCH, GARY S., San Jose, Calif. (San Jose State College)
SCHOFIELD, RUSSELL, Urbana, Ill. (Univ. of Ill., Research Asst.)

Tools, Materials, Services

Under this heading note is made of producer literature and products of presumed technical interest to ACI users of tools, equipment, materials, accessories, and special services.

Integral concrete coloring

Brochure describing the use and application of Sonobrite, integral coloring pigment, for concrete floor toppings, walls, sidewalls, brick mortar and cement plaster, has just been issued. Manufacturer advises that Sonobrite, made from selected metallic oxides, imparts a lasting, bright color without affecting tensile or compressive strength, and is immune to the action of free lime in cement and highly resistant to weathering. Brochure indicates red, green, buff, brown, and black shades available; gives detailed mixing instructions and specifies quantities required for use per bag of cement.—L. Sonneborn Sons, Inc., 404 Fourth Ave., New York 16, N. Y.

Prestressed concrete in the petroleum industry

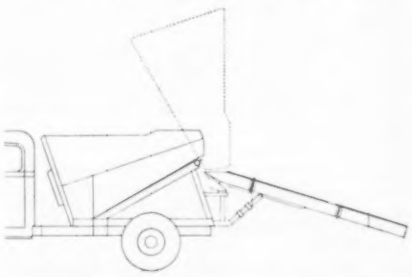
New technical bulletin (Preload Bulletin T-14) describes design and application advantages of prestressed concrete for the construction of storage tanks, fire walls, butane or propane storage vessels, containment vessels and shell foundations.—Preload Co., Inc., 211 East 37th St., New York, N. Y.

Release agent used in block manufacture

A liquid designed to prevent cinder and concrete block from adhering to metal pallets during drying is diluted with 20 parts of water, then sprayed on pallets. The manufacturer states that its freedom from gumminess makes Release Agent 787 superior to lubricating oil commonly used to coat pallets at less than half the cost of usual form or diesel oil application. Its flash point is said to be negligible, and it is nonflammable in dilution.—The Penetone Co., Box JAC-1-7, 74 Hudson Ave., Tenafly, N. J.

Eight-cu yd concrete carrier

An 8-cu yd Agitor has recently been introduced. This model, according to the manufacturer, can carry maximum legal loads for on-the-road hauls, and also



offers the possibility of carrying larger loads for off-the-road construction; can be used with pavers or central mixing plants. Listing advantages of this model the manufacturer cites its excellent concrete control during discharge; wide, fast folding and unfolding power-operated chutes; and a new front power take-off as optional equipment.—Agitor Division, S & M Manufacturing Co., 2901 W. Mill Road, Milwaukee 9, Wis.

Prestressed concrete tensioning materials

"Tensioning Materials for Prestressed Concrete," 15-page Catalog PC-936, shows tensioning elements best suited to given applications, including tabulated properties, detail drawings, illustrations, technical explanations, and pertinent prestressing data. Catalog covers uncoated stress-relieved strand for pre-tensioned bonded design and outstanding applications thereof; galvanized strand for post-tensioned design (example pictured is Cuyaguateje River Bridge in Cuba); anchor fittings for post-tensioned strands; and details for post-tensioned strands including bearing plate assembly,

end fittings, bearing plates, and typical jacking equipment. Prestressed slabs on grade are shown, and proper ties of uncoated stress-relieved wire are given. —Construction Materials Division, John A. Roebling's Sons Corp., Trenton 2, N. J.

Portable sand blasting machine

Introduction of the Model B6 portable Jet-Blaster, sand blasting machine has been announced. The machine has a 650-lb capacity, handles conventional abrasive materials, and has an adjustable flow control. It is designed for industrial and commercial uses such as removing corrosion, paint, concrete, or scale. — Air Placement Equipment Co., 1009 W. 24th, Kansas City, Mo.

Vermiculite concrete test report

A summary report covering a test program to demonstrate the adequacy of vermiculite concrete as a horizontal diaphragm is now available. Test results demonstrate the safety factor of vermiculite concrete roof decks in resisting earthquake loads. The report is of interest in areas subject to seismic disturbances, since it has become increasingly important in such areas to determine the ability of roof desk materials to resist lateral forces and to function as a horizontal diaphragm. —Vermiculite Institute, 208 South LaSalle St., Chicago 4, Ill.

Lightweight concrete bulletins

Two bulletins on lightweight concrete have been issued by Expanded Shale, Clay and Slate Institute. Modulus of elasticity values for various compressive strengths of expanded shale, clay, and slate concretes are presented in Information Sheet No. 5, "Suggested Design Coefficients;" one table of design coefficients is based on ACI's *Reinforced Concrete Design Handbook*. A second table compares strength and cross sections of heavy and lightweight concrete beams. Information

LOOKING AHEAD

January 6-10, 1958—Highway Research Board, Annual Meeting, Sheraton-Park Hotel, Washington, D. C.

January 16-18, 1958—National Concrete Products Association of Canada, Annual Convention, Chateau Laurier Hotel, Ottawa, Ont.

January 20-23, 1958—American Road Builders' Association, Annual Convention, Sheraton-Park Hotel, Washington, D. C.

January 26-30, 1958—Associated Equipment Distributors, 39th Annual Meeting, Conrad Hilton Hotel, Chicago.

January 27-31, 1958—University of Florida–Prestressed Concrete Institute, Second National Prestressed Concrete Short Course, Ellinor Village, Daytona Beach, Fla.

February 10-13, 1958—National Ready Mixed Concrete Association, 28th Annual Convention, Conrad Hilton Hotel, Chicago, Ill.

February 10-13, 1958—National Sand and Gravel Association, 42nd annual convention, Conrad Hilton Hotel, Chicago, Ill.

February 10-14, 1958—American Society for Testing Materials, Committee Week, Hotel Statler, St. Louis, Mo.

February 17-19, 1958—National Concrete Masonry Association, 38th Annual Convention, Chicago, Ill.

February 17-19, 1958—National Crushed Stone Association, 41st Annual Convention and Biennial Exposition of the Manufacturers Division, Hilton Hotel, Chicago, Ill.

February 24-26, 1958—National Concrete Products Association (Canada), Ninth Annual Convention, Seigniory Club, Montebello, Quebec.

February 24-26, 1958—National Concrete Contractors Association, 1st Annual Convention and 1958 Concrete Exposition, Chicago Coliseum, Chicago, Ill.

February 24-27, 1958—ACI 54th Annual Convention, Morrison Hotel, Chicago, Ill.

February 24-28, 1958—American Society of Civil Engineers, National Convention, Sherman Hotel, Chicago, Ill.

Sheet No. 6 gives suggested design coefficients for highway bridges.

A 15-page revised edition of "Bridge Deck Survey" brings up to date the 1953 survey of bridges in the United States and Canada whose deck construction incorporated lightweight expanded shale concrete. Some 40 structures had been built and reported on in 1954; since then over 30 structures have been added to the original tabulation. Data included are location and date of construction, owner, engineer, contractor, use and mix proportions of expanded shale concrete, wearing surface, type of traffic, and present condition of deck.—Expanded Shale, Clay and Slate Institute, 658 Warner Building, Washington, D. C.

STATEMENT REQUIRED BY THE ACT OF AUGUST 24, 1912, AS AMENDED BY THE ACTS OF MARCH 3, 1933, AND JULY 2, 1946 (Title 39, United States Code, Section 233) SHOWING THE OWNERSHIP, MANAGEMENT, AND CIRCULATION OF

JOURNAL OF THE AMERICAN CONCRETE INSTITUTE published twelve issues a year at Detroit, Mich., for September 1957.

1. The names and addresses of the publisher, editor, managing editor, and business managers are:
   Publisher, American Concrete Institute, 18263 W. McNichols Rd., Detroit 19, Mich.
   Editor, William A. Maples, 18263 W. McNichols Rd., Detroit 19, Mich.
   Managing editor, Robert E. Wilde, 18263 W. McNichols Rd., Detroit 19, Mich.
   Business manager, None

2. The owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding 1 percent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a partnership or other unincorporated firm, its name and address, as well as that of each individual member, must be given.)
   American Concrete Institute, 18263 W. McNichols Rd., Detroit 19, Mich.
   Walter H. Price, President, U. S. Bureau of Reclamation, Denver, Colo.
   Douglas McHenry, Vice-President, Portland Cement Association, Chicago, Ill.
   Phil M. Ferguson, Vice-President, University of Texas, Austin, Texas.

3. The known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

NONE

4. Paragraphs 2 and 3 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner.

5. The average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the 12 months preceding the date shown above was: (This information is required from daily, weekly, semiweekly, and triweekly newspapers only.)

WILLIAM A. MAPLES
(Signature of editor)

Sworn to and subscribed before me this 20th day of September, 1957.

JESSIE F. ALTENBERNT

(SEAL)

(My commission expires Mar. 11, 1960)

Concrete screw elevator

A screw elevator has handled most of the cement for the 448,300 cu yd of concrete for the 30-mile turnpike in Texas between Dallas and Fort Worth. Operating at a rail spur near the turnpike since August, 1956, the screw elevator loads a truck with 40-bbl capacity every 3 min; it is fed by a 12-in. Fort Worth Beeline screw conveyor extending beneath the rail spur to receive cement from the hopper cars. It is believed the first such use of a screw elevator, and the manufacturer states that it has demonstrated greater compactness, economy, and speed than bucket elevators previously used. This 12-in. diameter elevator has an 18-ft lift and discharges 150 tons of cement per hr. No permanent foundation is necessary for setup. The elevator and feeder conveyor may be driven from any convenient power source.—Fort Worth Steel & Machinery Co., Forth Worth, Tex.

Synchronized jacking catalog

Informative catalog featuring synchronized jacking systems lists hydraulic equipment available for prestressed concrete, pretensioning and post-tensioning equipment, and complete service facilities available. Contains some 20 pictures with data on recent construction jobs where the equipment has been used in the erection of hangar roofs, pile driving, prestressing, column load transfer, pipe pushing, bridges, bridge suspension, erection of power plant engines, etc. Includes several job "fact sheets" listing job, contractor, problem, and production equipment used.—Elgood Equipment Corp., 380 Ten Eyck St., Brooklyn 6, N. Y.

Fork lift offers "big tire" mobility

The Henry Tractor-Lift, designed to reduce on-the-job lifting costs, handles any job a regular lift-truck can handle, with the added advantages of big wheel traction and clearance, according to the manufacturer. Available at present for IHC and John Deere wheel and crawler tractors, three models are now on the market: TL-4316 features a three-rail mast and 16-ft lifting height that telescopes to 93 in., making it easy to clear low doors and overhangs; TL-2310, also a three-rail lift, goes 10 ft high and has a 64-in. down height; TL-4210 has a two-rail mast, affording a 10-ft lift and 87-in. down height. Each model offers three methods of mounting on the tractor: rear mount, rear mount with operator reversed, or front mount. Fork tines, made of heat-treated alloy steel, are available in 36- and 42-in. lengths.—Henry Manufacturing Co., Inc., Topeka, Kan.

ALPHABETICAL LIST OF ADVERTISERS

(Page Numbers refer to News Letter)

American Steel & Wire Division, United States Steel 18, 19
Colorado Fuel and Iron Corporation 12
Concrete Reinforcing Steel Institute 24
Jackson & Moreland 10
Laclede Steel Company 30
Lone Star Cement Corporation ..... Inside front cover
Master Builders Co., The 11
Servicised Products Corporation 28
Sika Chemical Corporation 21
Solvay Process Division, Allied Chemical & Dye Corporation 16
Sonoco Products Company 22
Universal Metal Hose Co. 25
Techkote Company 8

The Institute assumes no responsibility for the claims of advertisers. The advertiser is made responsible in the belief that his place in the field will be determined by the public's ultimate measure of his exercise of that responsibility.

Plastic cement for decorative finish

Orostone, a factory-mixed plastic cement with the appearance and permanence of stone, can be applied by trowel on the job. The finish of an Orostone surface is the result of a carefully maintained formula; crushed colored stones are mixed with a clear acrylic plastic. Desired colors and texture are obtained through a careful selection of the stone; no pigment is used. As a result Orostone is non-fading, wear-free, and virtually indestructible regardless of weather or climatic conditions, according to the producer.

Orostone was recently used on the curved dome roof of the Kresge Auditorium at Massachusetts Institute of Technology. Orostone may be applied to walls, panels, columns, soffits, or lintels and is said to offer unusual adhesion to concrete, brick, block, wood, asbestos boards, and metal.—California Stucco Products of New England, Inc., 169 Waverly St., Cambridge, Mass.

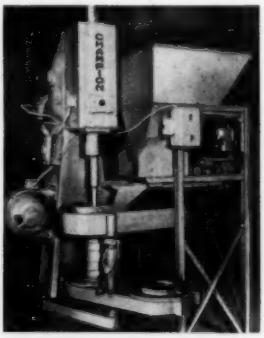
Calcium chloride manual

Complete and comprehensive manual on handling, storing, and applying calcium chloride has been published by Calcium Chloride Institute as Manual HM-1. In careful detail, and well illustrated with line drawings and photographs, the text tells how to store calcium chloride in bags or bulk, inside or outside, indicates procedures for handling the product, types of storage facilities, and preparation of facilities for short and long term storage in all seasons.

The manual also contains instructions for preparing calcium chloride solutions, and a section is given to winter maintenance applications. Although it is devoted primarily to the uses of calcium chloride in the highway industry (not as an accelerator in concrete), the text and illustrations apply to all situations where calcium chloride must be stored and handled. —Calcium Chloride Institute, 909 Ring Bldg., Washington 6, D. C.

One-man concrete tile production unit

Addition of a fully automatic feeder to the Champion concrete drain tile machine now permits one man to produce 300 concrete drain tile per hr, the manufacturer reports. Machine occupies only 16 sq ft of floor space, weighs 1500 lb, makes tile in a range of sizes from 3 to 12 in. in diameter. Mixed material from the feeder's hopper flows by gravity onto the hopper table in front of an impeller which directs a horizontal flow of the material into the shuttle on the feeding table of the machine. Length of the impeller stroke is adjusted according to the amount of material required in the shuttle for making different size tile. The shuttle is constantly agitated during feeding, so that the mixed material is thoroughly shaken into position within the casing. Both impeller and shuttle are stopped while mixed material is densely compacted in the mold by a packer head rotating at 500 rpm. As the packer head comes out of the mold, it brings excess material with it and throws it back on the feeder table.—W. E. Dunn Mfg. Co., 306 W. 24th St., Holland, Mich.



Detailing Practices

Buildings to Bridges

58 Illustrative Drawings

The ***Manual of Standard Practice for Detailing Reinforced Concrete Structures (ACI 315-57)*** incorporates under one cover the previous separate editions on detailing of buildings and highway structures. It is a correlation of the latest improved methods and standards for preparing drawings for the fabrication and placing of reinforcing steel. Sections on detailing and fabricating shop practice are translated into practical examples in typical drawings. Spiral bound to lie flat, it is the only publication of its kind in English and is meeting wide acclaim among designers, draftsmen, and engineering schools.

Full Price $4.00 **ACI Members $2.50**

AMERICAN CONCRETE INSTITUTE

PUBLICATIONS

P.O. Box 4754, Redford Station Detroit 19, Mich.

ACI Book of Standards

1957 Edition

Eleven ACI Standards in One Book

A collection of current ACI standards, recommended practices, and specifications. Your guide through a maze of construction problems.

$4.00

To ACI Members: **$2.00**

Recommended Practice for Evaluation of Compression Test Results of Field Concrete
(ACI 214-57)

Building Code Requirements for Reinforced Concrete
(ACI 318-56)

Reinforced Concrete Chimneys
(ACI 505-54)

Winter Concreting
(ACI 604-56)

Selecting Proportions for Concrete
(ACI 613-54)

Measuring, Mixing and Placing Concrete
(ACI 614-42)

Application of Portland Cement Paint
(ACI 616-49)

Concrete Pavements and Bases
(ACI 617-51)

Precast Concrete Floor Units
(ACI 711-53)

Construction of Concrete Farm Silos
(ACI 714-46)

Application of Mortar by Pneumatic Pressure
(ACI 805-51)

AMERICAN CONCRETE INSTITUTE

PUBLICATIONS

P.O. Box 4754, Redford Station Detroit 19, Mich.